ORIGINAL PAPER

OPTICAL PROPERTIES OF CdTe/CdS SOLAR CELLS DETERMINED BY INFRARED FOURIER TRANSFORMER (FTIR) SPECTROSCOPY

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Abstract. *CdS/CdTe solar cells have attracted much attention as the most suitable candidate for thin-film compound solar cells, and research is being conducted to establish the viability of these devices. Although the films are polycrystalline of just a few microns, the record efficiency of 16.7% has been obtained [1-2]. The achievement of higher voltages has been raised as a topic for future research, but it is thought that higher efficiency can be achieved by understanding the optical properties of CdS/CdTe interface and this is crucial for improving the multilayer CdS/CdTe device performance. In the present study, we have used the Infrared Fourier Transformer (FTIR) spectroscopy to determine the optical indexes n and k. These real and imaginary parts of visible and infrared refractive indexes of our multilayer system are determined by the Kramers-Kronig (KK) transformation of the reflectance spectra thanks to FTIR spectroscopy. It is expected that these cells will be an important semiconductor product and contribute to meeting the energy needs of the future.*

Keywords: *optical properties, CdTe, CdS, solar cells, FTIR, Kramers-Kronig, index of refraction, extinction coefficient*

1. INTRODUCTION

Films of cadmium telluride (CdTe) receive much attention as absorber materials for efficient, low cost solar cells [3]. Their advantages include high absorption coefficient, direct band gap with nearly optimum values for solar photovoltaics [4] and good match of their electron affinity to CdS as a window material.

Cadmium telluride (CdTe) is a compound semiconductor comprising of group II-IV elements having a cubic zinc blend (sphelerite) structure with a lattice constant of 6.481Å. CdTe is one of the few II-IV compounds used for the photoelectric energy conversion layer. The band gap energy of CdTe is 1.45 eV, which corresponds closely to sunlight spectrum. Since CdTe is a direct-transition-type band structure, the absorption coefficient is large for light with a wavelength below the absorption edge. Therefore, CdTe is a highly promising photovoltaic material to develop low cost and high-efficient solar cells.

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CdS has been found to be the best suited window material as a heterojunction partner in thin film CdTe solar cells.

The high short-circuit current density Isc is obtained in CdS/CdTe solar cells using thinner CdS film as window layer

$$I_{sc} = A.q/hc\int_{0}^{\infty} Hs(\lambda).\lambda.EQE(\lambda)d\lambda \tag{1}$$

where EQE is External Quantum Efficiency includes surface reflection losses R(λ) and H(λ) is solar irradiance.

Understanding the optical properties of CdS/CdTe interface is crucial for improving the multilayer CdS/CdTe device performance. In the present study, we have used the Infrared Fourier Transformer (FTIR) spectroscopy to determine the optical indexes n and k. These real and imaginary parts of visible and infrared refractive indices of our multilayer system are determined by the Kramers-Kronig (KK) transformation of the reflectance spectra thanks to FTIR spectroscopy.

FTIR (Infrared Fourier Transformer Spectrometer) use the technology of the Michelson Interferometer. A monochromatic light beam impinges on a light-splitting plate, which divides the beam into two parts of nearly equal intensity. One part passes through the plate, while the other is deflected perpendicular to the incident beam direction. Then both beams fall normally onto two mirrors and return to the beam-splitting plate. Once again, the plate partially reflects and partially transmits the incident light, producing an output beam composed of two beams that have traversed different arms of the interferometer. By moving one of the interferometer mirrors along the incident light beam, one can vary the optical path difference and observe a variation of the interference pattern.

The light-splitting plate is a plane-parallel glass plate the back surface of which is covered with a translucent silver film. The film is so thin that the plate partially reflects and partially transmits the light, thus serving as a semi-reflecting mirror.

FTIR's output is an interferogram and consists of a plot of detector signal versus the mirror displacement in the interferometer. The interferogram must be mathematically transform to a more conventional "% transmission versus wavelength" spectrum by means of Fourier-Transform methods. This is done in a computer which is also used to control the spectrometer [10].

2. EXPERIMENTAL

2.1. FILM PREPARATION

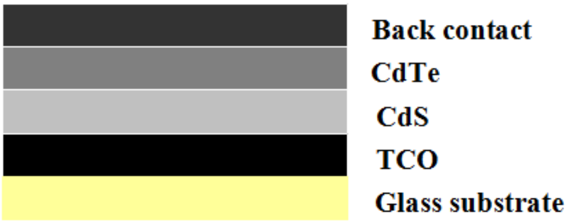

Fig. 1. The structure of the CdS/CdTe thin film solar cell

Figure 1 shows the schematic cross-sectional view of thin film CdS/CdTe solar cell. This structure is the super striate type configuration, Glass/TCO(Transparent Conducting Oxide)/CdS/CdTe/Back contact.

Specifications for glass substrate

It is choosen the glass substrate presented in table below with following details: critical for the quality of the deposited films (impurties out-diffusion); toughened glass is not an option because of the process temperature; temperature stability is important to minimise the defect density in the films. In thid case the higher temperature glass (Borosilicate) is preferred but we use the sodaline at lower temperature due to lower cost. CdTe has a high work function of 5.8eV. We are used SnO_2 deposited by LPCVD from Tin Tetrachloride source @ 500-600°C. Development work with CdTe homojunctions has not been successful looking for heterojunction with a large band gap “window” layer; Possible candidates can be CdS, ZnSe, ZnS, $Zn_xCd_{1-x}S$. We have used the most successful the CdS, but it band gap 2.42 eV so we need to minimize the thickness (0.8μm). Polycristalline CdTe is difficult to dope p-type extrinsically (dopant segregates at GB) Most contacts are Cu-based, but Cu containing contacts are suspect for stability. Cu is an acceptor dopant for CdTe. Copper added to graphite contacts is used. [7-9]

Glass Type	CTE	Softening	Strain point
Sodalime	9.35 10^{-6} /°C	696 °C	473 °C
Borosilicate	5.2 10^{-6} /°C	815 °C	640 °C

2. 2. MEASUREMENT EQUIPMENT

A complete FTIR assembly is shown in Fig. 2. Since collection of a usable spectrum takes only a few minutes the reference data may be collected immediately before or after the sample data without disturbances due to changing humidity, etc. Technical details of the used equipment: Spectrometer Bruker Vertex 70; KBr beamsplitter; Michaelson interferometer: ROCKSOLID configuration, permanently aligned; Source: HeNe laser, 633 nm, 1mW; Acquisition & control software: OPUS 6.0. Performances of device: IR spectral range: 850-7500 cm^{-1}; visible spectral range: 9500-25000 cm^{-1}; resolution: 2 cm^{-1}.

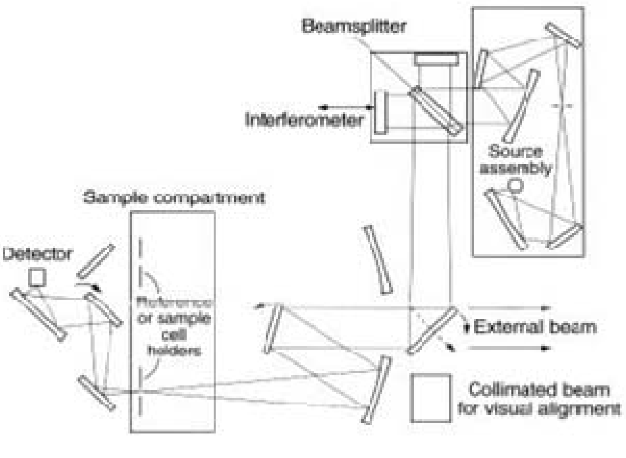

Fig. 2. Optical path.

In figures 3 and 4 are presented the FTIR visible and infrared spectra’s of the multilayer function of wavelength.

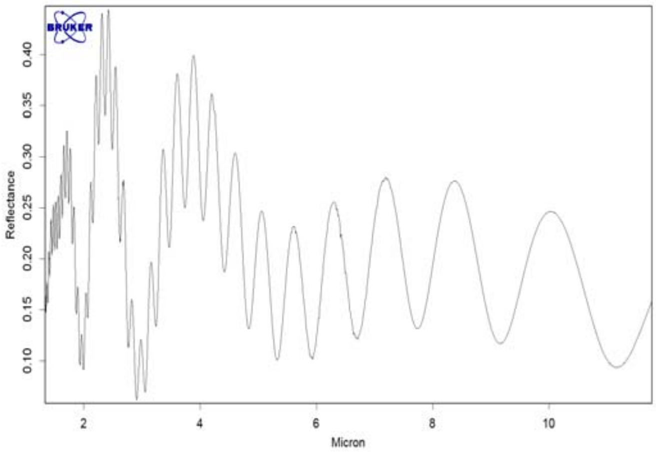

Fig. 3. Tipycal infrared spectum of a stydied sample.

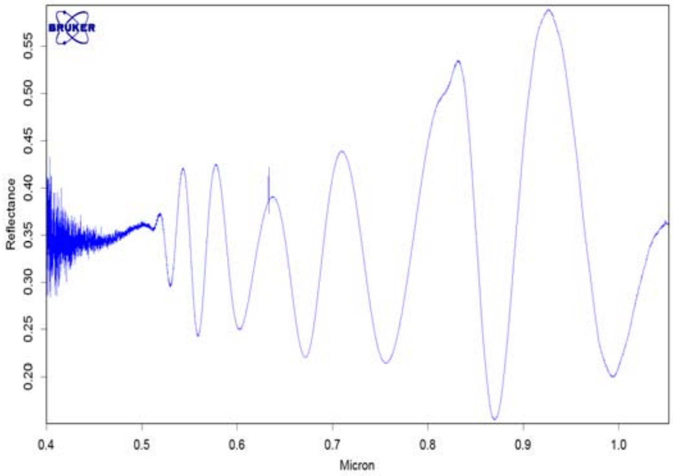

Fig. 4. FTIR visible spectra

3. RESULTS AND DISCUSSION

The Kramers-Kronig (KK) method has long been used to analyse the reflection spectra to determine the various optical constants of substances n and k [11-20].

From a KK transform of the reflectance data we calculate the index of refraction n(ω) and the extinction coefficient k(ω) as functions of frequency. These properties are fundamental material characteristics, as they effectively define its optical response to light. The Kramers-Kronig relationships provide fundamental rules for the relationships between the real and imaginary parts of the spectrum of any real physically quantity when expressed as a complex function of frequency [12-22].

At normal incidence, the complex reflectivity $r(\omega)$ of light is related to amplitude and phase:

$$r(\omega) = E_{refl} / E_{inc} = \rho(\omega)\exp[i\theta(\omega)] \tag{2}$$

where E is the reflected electric field vector and θ is the phase of the reflection coefficient.

The quantity obtained from the reflectance measurement is usually the amplitude of the reflected beam, which is the square of the modulus of the complex reflectivity:

$$R(\omega) = \left| E_{refl} / E_{inc} \right|^2 = \rho^2(\omega) \tag{3}$$

And the KK integral related the phase shift to the reflectance:

$$\theta(\omega) = \frac{\omega}{\Pi}\int_0^\infty \frac{\ln[R(\omega')] - \ln[R(\omega)]}{\omega^2 - \omega'^2} d\omega' \tag{4}$$

Even though the data were obtained over a wide frequency range, extrapolation beyond the frequency interval of interest is necessary, as the integral in equation (4) extends from 0 to infinity. Using relation (5):

$$r(\omega) = \frac{(n-1)+ik}{(n+1)+ik} \tag{5}$$

The refractive index and the extinction coefficient can be calculated, respectively, from equations (6) and (7):

$$n(\omega) = \frac{1-R(\omega)}{1+R(\omega)-2[R(\omega)]^{1/2}\cos\theta(\omega)} \tag{6}$$

$$k(\omega) = 2\frac{[R(\omega)]^{1/2}\sin\theta(\omega)}{1+R(\omega)-2[R(\omega)]^{1/2}\cos\theta(\omega)} \tag{7}$$

where ω the frequency [cm^{-1}].

Therefore, by Kramers-Kronig transforms of reflectance data, we can therefore establish the optical constants of a material.

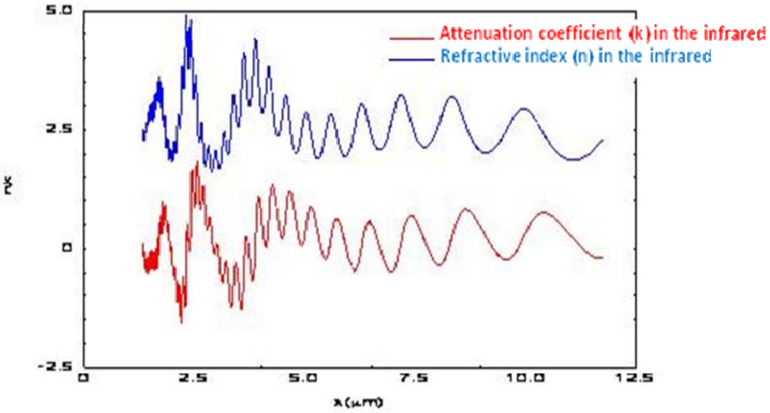

Fig. 5. n and k IR spectra of analyzed samples.

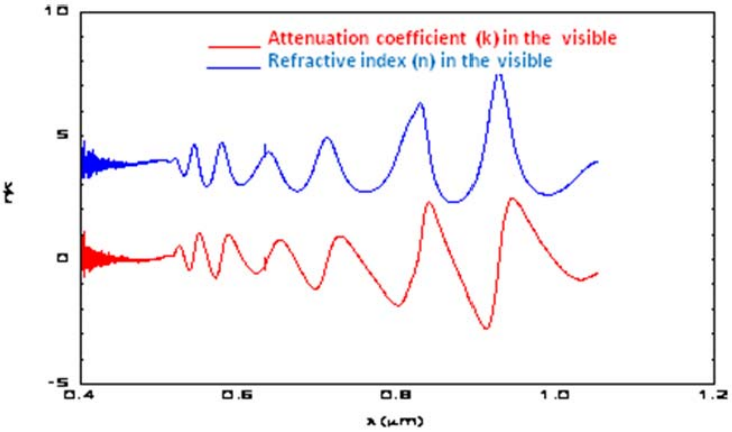

Fig. 6. n and k visible spectra of analyzed samples.

The results of n and k function of wavelength in a part of IR domain and visible, are shown respectively in table1 and table 2.

4. CONCLUSIONS

We can conclude that the important advantage of the FTIR spectrometer is that it was faster and more sensitive, so that smaller samples can be analyzed and a maximum signal can be collected in a very short time.

We have presented a detailed description of the use of Kramers-Kronig (KK) method to analyze the normal incidence infrared (IR) reflectance spectra.

The results we have achieved through this work can find a solution to some problems often encountered in the calculations of optical coefficients of materials. Indeed, in most, tables of optical constants measured [23], the existence of empty areas or the index of refraction or extinction present an obstacle to calculate reflection, transmission and absorption. But this work, we could fill this leak on the reference's table by determining a continuous series with more optical indexes of refraction and extinction values with great accuracy (precision of 10^{-6}).

Table 1. n and k function of wavelength in part of infrared (2.56947- 2.5904 µm) for samples.

λ[µm]	n	k	λ[µm]	n	k	λ[µm]	n	k
2.56947	2.619	1.7278	2.57668	2.46248	1.62397	2.58388	2.34291	1.49183
2.56982	2.61548	1.71999	2.57702	2.46166	1.61217	2.58423	2.34786	1.47848
2.57016	2.61438	1.71633	2.57736	2.46263	1.60537	2.58457	2.35341	1.47116
2.5705	2.61044	1.71657	2.57771	2.46381	1.60199	2.58491	2.35896	1.46912
2.57085	2.60384	1.71721	2.57805	2.46223	1.60306	2.58525	2.35933	1.4717
2.57119	2.59462	1.7178	2.57839	2.45606	1.60379	2.5856	2.35493	1.47354
2.57153	2.58355	1.71654	2.57874	2.44826	1.6031	2.58594	2.34694	1.47404
2.57188	2.57187	1.71364	2.57908	2.43898	1.60105	2.58628	2.33658	1.47111
2.57222	2.55984	1.7093	2.57942	2.42926	1.59743	2.58663	2.32477	1.46452
2.57256	2.54697	1.70274	2.57977	2.4192	1.59283	2.58697	2.31502	1.45125
2.57291	2.5361	1.69245	2.58011	2.40791	1.5868	2.58731	2.31267	1.43704
2.57325	2.52888	1.68173	2.58045	2.39675	1.57679	2.58766	2.31352	1.42575
2.57359	2.52466	1.67118	2.5808	2.38927	1.56453	2.588	2.31731	1.41787
2.57394	2.52409	1.66426	2.58114	2.38496	1.55191	2.58834	2.3191	1.41586
2.57428	2.52144	1.662	2.58148	2.38564	1.54112	2.58869	2.31605	1.41352
2.57462	2.51612	1.66007	2.58182	2.38678	1.53672	2.58903	2.31229	1.40915
2.57496	2.5091	1.65827	2.58217	2.38432	1.53461	2.58937	2.30828	1.40353
2.57531	2.50039	1.6555	2.58251	2.37874	1.53374	2.58971	2.30604	1.39646
2.57565	2.49051	1.6514	2.58285	2.36835	1.53042	2.59006	2.30582	1.39146
2.57599	2.48024	1.64506	2.5832	2.35754	1.52264	2.5904	2.30427	1.38857

Table. 2. n and k function of wavelength in part of visible (0.492718- 0.496021 µm) for samples.

λ[µm]	n	k	λ[µm]	n	k	λ[µm]	n	k
0.492718	3.9754	0.001177	0.493984	3.98953	0.019424	0.495064	3.96132	0.030361
0.492749	3.97189	0.003047	0.494014	3.99251	0.023695	0.495156	4.01908	0.013816
0.492872	3.98811	0.021072	0.494045	3.98097	0.032292	0.495187	4.00416	0.022334
0.492903	3.96649	0.013211	0.494076	3.96711	0.019551	0.495218	4.01084	0.015769
0.492934	3.97182	0.00182	0.494107	3.97817	0.00149	0.495249	4.0234	0.029769
0.492965	3.97336	0.003747	0.494138	4.00113	0.011887	0.49528	4.01828	0.052154
0.492996	3.97431	0.003469	0.494169	3.99127	0.037211	0.495311	3.99796	0.06452
0.493027	3.96805	0.006071	0.4942	3.97184	0.031209	0.495342	3.97478	0.059239
0.49315	3.99338	0.007852	0.49423	3.97232	0.024823	0.495372	3.96506	0.038268
0.493181	3.98505	0.011691	0.494261	3.96743	0.024398	0.495403	3.97785	0.022298

0.493212	3.97625	0.013601
0.493243	3.96599	0.002009
0.493366	4.00372	0.003097
0.493397	3.99653	0.014243
0.493428	3.99453	0.013016
0.493459	3.9949	0.022493
0.49349	3.98085	0.027511
0.493521	3.97045	0.016364
0.493551	3.97702	0.003125
0.493582	3.9901	0.006593
0.493613	3.99019	0.016291
0.493644	3.98684	0.021239
0.493675	3.98	0.024654
0.493706	3.97316	0.02285
0.493737	3.96641	0.017878
0.493768	3.9656	0.007683
0.493798	3.97012	0.001709
0.493922	4.00539	0.009323
0.493953	3.99581	0.022108
0.494292	3.96194	0.018088
0.494323	3.96098	0.00575
0.494385	3.98577	0.00593
0.494416	3.98173	0.017194
0.494447	3.9679	0.017199
0.494601	3.99933	0.005361
0.494632	3.99138	0.012085
0.494663	3.99532	0.005407
0.494693	4.00466	0.01716
0.494724	3.99265	0.030014
0.494755	3.98104	0.023493
0.494786	3.98047	0.01849
0.494817	3.97759	0.013035
0.494848	3.98238	0.006032
0.494879	3.98587	0.004399
0.49494	4.01471	0.005068
0.494971	4.01433	0.028745
0.495002	4.00095	0.039417
0.495033	3.98398	0.044241
0.495434	3.99498	0.029502
0.495465	3.99086	0.047419
0.495496	3.97625	0.04807
0.495527	3.97114	0.045405
0.495558	3.95848	0.043401
0.495589	3.94791	0.023106
0.49565	3.99628	0.006032
0.495681	3.99451	0.034519
0.495712	3.97576	0.037307
0.495743	3.96655	0.029267
0.495774	3.966	0.01291
0.495805	3.98555	0.007744
0.495835	3.99051	0.024523
0.495866	3.97947	0.025823
0.495897	3.98311	0.019424
0.495928	3.98655	0.027396
0.495959	3.97735	0.028537
0.49599	3.97699	0.022378
0.496021	3.97928	0.019599

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APPENDIX:
TABLE OF OPTICAL CONSTANTS n AND k

Table. 1. The optical constants n and k with the corresponding wavelength in the infrared region

λ[μm]	n	k
2.39453	4.38514	0.00176
2.39487	4.39631	0.007435
2.39522	4.4076	0.013367
2.39556	4.41889	0.019621
2.3959	4.43019	0.026156
2.39625	4.44149	0.033007
2.39659	4.45274	0.040188
2.39693	4.46392	0.047679
2.39727	4.47498	0.055435
2.39762	4.48596	0.063425
2.39796	4.49687	0.071575
2.3983	4.50787	0.07988
2.39865	4.51902	0.08852
2.39899	4.53033	0.097665
2.39933	4.54145	0.107545
2.39967	4.55213	0.11785
2.40002	4.56236	0.128399
2.40036	4.5723	0.138858
2.4007	4.58234	0.149434
2.40105	4.59231	0.160333
2.40139	4.6022	0.17161
2.40173	4.6117	0.183183
2.40208	4.62101	0.194759
2.40242	4.6303	0.206467
2.40276	4.63964	0.218379
2.40311	4.64899	0.230707
2.40345	4.65816	0.243454
2.40379	4.66711	0.256573
2.40413	4.67578	0.270014
2.40448	4.68413	0.283706
2.40482	4.69222	0.297544
2.40516	4.70018	0.311593
2.40551	4.70794	0.325916
2.40585	4.7155	0.340548
2.40619	4.72267	0.355437
2.40654	4.72963	0.370397
2.40688	4.73644	0.38557
2.40722	4.74316	0.400997
2.40757	4.74969	0.416952
2.40791	4.75569	0.433283
2.40825	4.76119	0.449831
2.40859	4.76615	0.466371
2.40894	4.77094	0.482867
2.40928	4.77551	0.499528
2.40962	4.77989	0.516373
2.40997	4.78391	0.533503
2.41031	4.78756	0.550712
2.41065	4.79091	0.568051
2.411	4.79402	0.585495
2.41134	4.7969	0.603207
2.41168	4.79938	0.621186
2.41202	4.8014	0.639436
2.41237	4.80281	0.657801
2.41271	4.80368	0.676134
2.41305	4.80407	0.694298
2.4134	4.80426	0.712288
2.41374	4.80424	0.7303
2.41408	4.80407	0.748418
2.41443	4.80348	0.766796
2.41477	4.80243	0.785177
2.41511	4.80089	0.80355
2.41546	4.79905	0.821672
2.4158	4.79708	0.83985
2.41614	4.79491	0.85812
2.41648	4.79239	0.876792
2.41683	4.78908	0.895574
2.41717	4.78508	0.914218
2.41751	4.78045	0.932381
2.41786	4.77572	0.950061
2.4182	4.77094	0.967527
2.41854	4.76623	0.985007
2.41888	4.7613	1.00272
2.41923	4.75603	1.02059
2.41957	4.75027	1.03857
2.41991	4.744	1.05655
2.42026	4.73714	1.07442
2.4206	4.72978	1.09207
2.42094	4.72197	1.10937
2.42129	4.71394	1.12637
2.42163	4.70564	1.14321
2.42197	4.69708	1.15987
2.42231	4.68822	1.17637
2.42266	4.67908	1.19275
2.423	4.66958	1.209
2.42334	4.65966	1.22512
2.42369	4.64921	1.24089
2.42403	4.63848	1.2562
2.42437	4.62756	1.27105
2.42472	4.61667	1.28556
2.42506	4.60572	1.29993
2.4254	4.59472	1.31421
2.42575	4.58348	1.32847
2.42609	4.572	1.34266
2.42643	4.56018	1.35681
2.42677	4.54793	1.37086
2.42712	4.53513	1.38469
2.42746	4.52179	1.39811
2.4278	4.50805	1.41082
2.42815	4.49434	1.42296
2.42849	4.48056	1.43473
2.42883	4.46682	1.44619
2.42918	4.4528	1.45741
2.42952	4.43876	1.46804
2.42986	4.42485	1.47837
2.43021	4.41118	1.48844
2.43055	4.39763	1.49876
2.43089	4.38372	1.50921
2.43123	4.36931	1.51969
2.43158	4.35414	1.52971
2.43192	4.33873	1.53899
2.43226	4.32325	1.54761
2.43261	4.30805	1.55574
2.43295	4.29291	1.56382
2.43329	4.2776	1.57171
2.43363	4.26195	1.57936
2.43398	4.24599	1.58638
2.43432	4.23	1.59274
2.43466	4.21419	1.59834
2.43501	4.19887	1.6035
2.43535	4.18395	1.60842
2.43569	4.16944	1.61338
2.43604	4.15498	1.61844
2.43638	4.14052	1.6236
2.43672	4.12579	1.62872
2.43707	4.11088	1.63366
2.43741	4.09571	1.63826
2.43775	4.08055	1.64248
2.4381	4.06537	1.64641
2.43844	4.05027	1.65009
2.43878	4.03503	1.65361
2.43912	4.0197	1.65673
2.43947	4.00429	1.65947

λ[µm]	n	k
2.43981	3.98899	1.66168
2.44015	3.97393	1.66358
2.4405	3.95908	1.66522
2.44084	3.9444	1.66676
2.44118	3.92971	1.66815
2.44152	3.91504	1.66928
2.44187	3.90043	1.67013
2.44221	3.88594	1.6707
2.44255	3.8716	1.67108
2.4429	3.85726	1.67126
2.44324	3.84305	1.67112
2.44358	3.82901	1.67075
2.44393	3.8152	1.67014
2.44427	3.80159	1.66956
2.44461	3.78795	1.66891
2.44496	3.77423	1.66813
2.4453	3.76039	1.667
2.44564	3.74666	1.66542
2.44598	3.73318	1.66349
2.44633	3.72002	1.66132
2.44667	3.70714	1.65905
2.44701	3.69444	1.65671
2.44736	3.68189	1.65428
2.4477	3.66944	1.65175
2.44804	3.65715	1.6491
2.44839	3.64495	1.6464
2.44873	3.63281	1.6436
2.44907	3.62067	1.64067
2.44941	3.60856	1.6375
2.44976	3.59661	1.63408
2.4501	3.58481	1.63052
2.45044	3.57313	1.6268
2.45079	3.56152	1.62293
2.45113	3.54999	1.61875
2.45147	3.53874	1.61428
2.45182	3.5278	1.60961
2.45216	3.51725	1.60487
2.4525	3.507	1.60019
2.45285	3.49697	1.59565
2.45319	3.48693	1.59131
2.45353	3.47677	1.58703
2.45387	3.46622	1.58257
2.45422	3.45566	1.57747
2.45456	3.44538	1.5719

λ[µm]	n	k
2.43981	3.98899	1.66168
2.44015	3.97393	1.66358
2.4405	3.95908	1.66522
2.44084	3.9444	1.66676
2.44118	3.92971	1.66815
2.44152	3.91504	1.66928
2.44187	3.90043	1.67013
2.44221	3.88594	1.6707
2.44255	3.8716	1.67108
2.4429	3.85726	1.67126
2.44324	3.84305	1.67112
2.44358	3.82901	1.67075
2.44393	3.8152	1.67014
2.44427	3.80159	1.66956
2.44461	3.78795	1.66891
2.44496	3.77423	1.66813
2.4453	3.76039	1.667
2.44564	3.74666	1.66542
2.44598	3.73318	1.66349
2.44633	3.72002	1.66132
2.44667	3.70714	1.65905
2.44701	3.69444	1.65671
2.44736	3.68189	1.65428
2.4477	3.66944	1.65175
2.44804	3.65715	1.6491
2.44839	3.64495	1.6464
2.44873	3.63281	1.6436
2.44907	3.62067	1.64067
2.44941	3.60856	1.6375
2.44976	3.59661	1.63408
2.4501	3.58481	1.63052
2.45044	3.57313	1.6268
2.45079	3.56152	1.62293
2.45113	3.54999	1.61875
2.45147	3.53874	1.61428
2.45182	3.5278	1.60961
2.45216	3.51725	1.60487
2.4525	3.507	1.60019
2.45285	3.49697	1.59565
2.45319	3.48693	1.59131
2.45353	3.47677	1.58703
2.45387	3.46622	1.58257
2.45422	3.45566	1.57747
2.45456	3.44538	1.5719

λ[µm]	n	k
2.4549	3.43572	1.56587
2.45525	3.42675	1.56009
2.45559	3.41793	1.55458
2.45593	3.40917	1.54932
2.45627	3.40015	1.54402
2.45662	3.39122	1.53841
2.45696	3.38243	1.53264
2.4573	3.37391	1.52669
2.45765	3.36561	1.52074
2.45799	3.35751	1.51476
2.45833	3.34952	1.50882
2.45868	3.34161	1.50284
2.45902	3.33375	1.4968
2.45936	3.32599	1.49056
2.45971	3.31846	1.48419
2.46005	3.31118	1.47774
2.46039	3.30417	1.47133
2.46074	3.29728	1.46501
2.46108	3.29044	1.45876
2.46142	3.28354	1.45248
2.46176	3.27665	1.44599
2.46211	3.26985	1.43926
2.46245	3.26336	1.43222
2.46279	3.2573	1.42512
2.46314	3.25159	1.41808
2.46348	3.24618	1.41126
2.46382	3.24081	1.4046
2.46416	3.2355	1.39803
2.46451	3.23014	1.39145
2.46485	3.22491	1.38477
2.46519	3.21977	1.37805
2.46554	3.21483	1.37128
2.46588	3.21	1.36456
2.46622	3.2053	1.35784
2.46657	3.20064	1.35114
2.46691	3.19608	1.34438
2.46725	3.19153	1.33757
2.4676	3.18711	1.33055
2.46794	3.18295	1.32344
2.46828	3.17909	1.31624
2.46862	3.17557	1.3092
2.46897	3.17218	1.30236
2.46931	3.16883	1.29571
2.46965	3.16539	1.28911

λ[µm]	n	k
2.47	3.1619	1.28243
2.47034	3.15847	1.27562
2.47068	3.15512	1.26869
2.47103	3.15194	1.26169
2.47137	3.14873	1.25463
2.47171	3.14566	1.24716
2.47205	3.14296	1.23947
2.4724	3.14084	1.2315
2.47274	3.13951	1.22383
2.47308	3.13851	1.21666
2.47343	3.13768	1.21003
2.47377	3.13664	1.20381
2.47411	3.13543	1.19773
2.47446	3.13401	1.19169
2.4748	3.1325	1.18556
2.47514	3.13096	1.1793
2.47549	3.1295	1.17288
2.47583	3.12818	1.16631
2.47617	3.12714	1.15967
2.47651	3.1263	1.1531
2.47686	3.12564	1.14657
2.4772	3.12511	1.14014
2.47754	3.1247	1.13372
2.47789	3.1245	1.12734
2.47823	3.12448	1.12114
2.47857	3.12454	1.11512
2.47891	3.12454	1.10933
2.47926	3.12434	1.1035
2.4796	3.12414	1.09752
2.47994	3.12398	1.09129
2.48029	3.12419	1.08489
2.48063	3.12469	1.07858
2.48097	3.12547	1.07236
2.48132	3.12637	1.06636
2.48166	3.12732	1.06041
2.482	3.12842	1.05452
2.48235	3.12968	1.04873
2.48269	3.13106	1.04307
2.48303	3.13247	1.03765
2.48338	3.13368	1.03224
2.48372	3.13494	1.02665
2.48406	3.1363	1.02085
2.4844	3.13817	1.01486
2.48475	3.14047	1.00919
2.48509	3.143	1.00379
2.48543	3.14559	0.998851
2.48578	3.14799	0.994059
2.48612	3.15039	0.98929
2.48646	3.15282	0.984581
2.4868	3.15526	0.979925
2.48715	3.15773	0.975311
2.48749	3.16015	0.970678
2.48783	3.16271	0.965819
2.48818	3.16561	0.96097
2.48852	3.1688	0.956202
2.48886	3.1723	0.951756
2.48921	3.17578	0.947618
2.48955	3.17925	0.943625
2.48989	3.18271	0.939747
2.49024	3.18622	0.935911
2.49058	3.18983	0.932211
2.49092	3.19344	0.928674
2.49126	3.19701	0.925179
2.49161	3.20059	0.921704
2.49195	3.20426	0.918149
2.49229	3.20821	0.914648
2.49264	3.21229	0.911392
2.49298	3.21644	0.908355
2.49332	3.22042	0.905578
2.49367	3.22421	0.902647
2.49401	3.22806	0.899557
2.49435	3.23211	0.896148
2.49469	3.23685	0.892764
2.49504	3.24194	0.889821
2.49538	3.24727	0.887347
2.49572	3.25243	0.885452
2.49607	3.25731	0.88366
2.49641	3.26209	0.881919
2.49675	3.26684	0.880142
2.4971	3.2717	0.878412
2.49744	3.27663	0.876793
2.49778	3.28162	0.875295
2.49813	3.28665	0.873921
2.49847	3.29171	0.872669
2.49881	3.29676	0.871515
2.49915	3.30184	0.87035
2.4995	3.30712	0.869245
2.49984	3.31255	0.868285
2.50018	3.3182	0.867588
2.50053	3.32384	0.867262
2.50087	3.32941	0.867236
2.50121	3.33468	0.867462
2.50155	3.33973	0.867646
2.5019	3.34454	0.867731
2.50224	3.34942	0.867363
2.50258	3.35471	0.866869
2.50293	3.36054	0.866313
2.50327	3.36701	0.866354
2.50361	3.37348	0.867086
2.50396	3.37981	0.868445
2.5043	3.38549	0.87016
2.50464	3.39083	0.87165
2.50499	3.396	0.872947
2.50533	3.40137	0.873862
2.50567	3.40719	0.874826
2.50602	3.41342	0.875975
2.50636	3.41998	0.877728
2.5067	3.42636	0.880007
2.50704	3.4326	0.882643
2.50739	3.43852	0.885509
2.50773	3.4443	0.88839
2.50807	3.45002	0.891379
2.50842	3.45575	0.894433
2.50876	3.46149	0.897707
2.5091	3.46721	0.901176
2.50944	3.47283	0.904965
2.50979	3.47816	0.908912
2.51013	3.4833	0.912878
2.51047	3.48832	0.916807
2.51082	3.49334	0.920661
2.51116	3.49846	0.92454
2.5115	3.50368	0.928517
2.51185	3.50902	0.932636
2.51219	3.51449	0.936978
2.51253	3.52005	0.941634
2.51288	3.52567	0.946711
2.51322	3.53106	0.952334
2.51356	3.53604	0.958263
2.5139	3.54052	0.964374
2.51425	3.54454	0.970261
2.51459	3.54849	0.975922
2.51493	3.5524	0.981383

λ[µm]	n	k
2.51528	3.55656	0.986779
2.51562	3.56082	0.992318
2.51596	3.5652	0.997976
2.51631	3.56961	1.00387
2.51665	3.57405	1.00987
2.51699	3.57869	1.0161
2.51733	3.58342	1.02287
2.51768	3.58788	1.03013
2.51802	3.59198	1.03784
2.51836	3.59528	1.04558
2.51871	3.59849	1.05283
2.51905	3.60181	1.06003
2.51939	3.60552	1.06719
2.51974	3.60951	1.07507
2.52008	3.61316	1.08353
2.52042	3.61639	1.09244
2.52077	3.61899	1.10152
2.52111	3.6212	1.11048
2.52145	3.62323	1.11948
2.52179	3.62497	1.12856
2.52214	3.62645	1.13779
2.52248	3.62714	1.14713
2.52282	3.62732	1.15571
2.52317	3.62748	1.16371
2.52351	3.62809	1.17074
2.52385	3.6302	1.17797
2.52419	3.63271	1.18635
2.52454	3.63524	1.19576
2.52488	3.63684	1.2063
2.52522	3.63731	1.21676
2.52557	3.63718	1.227
2.52591	3.63663	1.23676
2.52625	3.63614	1.24621
2.5266	3.63572	1.25547
2.52694	3.6357	1.26491
2.52728	3.63562	1.27488
2.52763	3.63536	1.28538
2.52797	3.63432	1.29644
2.52831	3.63247	1.30738
2.52866	3.63005	1.31811
2.529	3.62723	1.32839
2.52934	3.62447	1.33851
2.52968	3.62126	1.34898
2.53003	3.61713	1.35911
2.53037	3.6124	1.36859
2.53071	3.60717	1.37663
2.53106	3.60329	1.38325
2.5314	3.60073	1.39023
2.53174	3.59892	1.39771
2.53208	3.59743	1.40621
2.53243	3.59561	1.41529
2.53277	3.59384	1.42454
2.53311	3.59254	1.43481
2.53346	3.59029	1.44667
2.5338	3.58657	1.45918
2.53414	3.58072	1.47194
2.53449	3.57304	1.48325
2.53483	3.56413	1.4929
2.53517	3.55531	1.49934
2.53552	3.54872	1.50424
2.53586	3.54454	1.50802
2.5362	3.54443	1.51386
2.53654	3.54404	1.52392
2.53689	3.54211	1.53603
2.53723	3.53723	1.5498
2.53757	3.52958	1.56202
2.53792	3.52132	1.57279
2.53826	3.5128	1.58208
2.5386	3.50522	1.59074
2.53895	3.49787	1.5996
2.53929	3.49078	1.6088
2.53963	3.48306	1.61874
2.53997	3.47442	1.62869
2.54032	3.46477	1.63849
2.54066	3.45416	1.6476
2.541	3.44264	1.65581
2.54135	3.43069	1.66254
2.54169	3.41847	1.66778
2.54203	3.40725	1.67054
2.54238	3.39852	1.67275
2.54272	3.39157	1.67514
2.54306	3.38674	1.67934
2.54341	3.3811	1.68605
2.54375	3.37426	1.69305
2.54409	3.36684	1.70026
2.54443	3.35893	1.70717
2.54478	3.35151	1.71428
2.54512	3.34359	1.72284
2.54546	3.33408	1.73181
2.54581	3.32283	1.74103
2.54615	3.30907	1.74867
2.54649	3.29473	1.75384
2.54683	3.28025	1.75613
2.54718	3.26864	1.75577
2.54752	3.25983	1.75557
2.54786	3.25414	1.75638
2.54821	3.24945	1.76134
2.54855	3.24281	1.76852
2.54889	3.23396	1.7774
2.54924	3.22146	1.78548
2.54958	3.20767	1.79131
2.54992	3.19294	1.79468
2.55027	3.18004	1.79522
2.55061	3.16931	1.79603
2.55095	3.15954	1.7973
2.5513	3.15018	1.80031
2.55164	3.13834	1.80363
2.55198	3.12614	1.8043
2.55232	3.11522	1.8038
2.55267	3.1064	1.80189
2.55301	3.10127	1.80204
2.55335	3.09554	1.80606
2.5537	3.08807	1.81148
2.55404	3.07826	1.818
2.55438	3.06603	1.82307
2.55472	3.05351	1.82671
2.55507	3.04072	1.82926
2.55541	3.02846	1.83104
2.55575	3.01631	1.83267
2.5561	3.00425	1.83406
2.55644	2.99207	1.83531
2.55678	2.97984	1.83632
2.55713	2.96741	1.83715
2.55747	2.95486	1.83777
2.55781	2.9419	1.83821
2.55816	2.92857	1.83833
2.5585	2.91434	1.8379
2.55884	2.89967	1.83614
2.55918	2.88464	1.83293
2.55953	2.87032	1.82746
2.55987	2.85762	1.82079
2.56021	2.84677	1.81309

λ[μm]	n	k
2.56056	2.83829	1.80577
2.5609	2.83114	1.79936
2.56124	2.82522	1.79432
2.56159	2.819	1.79085
2.56193	2.81236	1.78754
2.56227	2.80618	1.78452
2.56261	2.80009	1.7824
2.56296	2.79377	1.78099
2.5633	2.78669	1.78079
2.56364	2.77718	1.7801
2.56399	2.76784	1.77668
2.56433	2.76039	1.7728
2.56467	2.75458	1.76887
2.56502	2.75113	1.76753
2.56536	2.7457	1.76983
2.5657	2.73757	1.77238
2.56605	2.72722	1.77486
2.56639	2.71487	1.77546
2.56673	2.70221	1.7743
2.56707	2.68949	1.77149
2.56742	2.67753	1.76747
2.56776	2.66612	1.7628
2.5681	2.65527	1.75756
2.56845	2.64469	1.75203
2.56879	2.6339	1.74521
2.56913	2.62508	1.73633
2.56947	2.619	1.7278
2.56982	2.61548	1.71999
2.57016	2.61438	1.71633
2.5705	2.61044	1.71657
2.57085	2.60384	1.71721
2.57119	2.59462	1.7178
2.57153	2.58355	1.71654
2.57188	2.57187	1.71364
2.57222	2.55984	1.7093
2.57256	2.54697	1.70274
2.57291	2.5361	1.69245
2.57325	2.52888	1.68173
2.57359	2.52466	1.67118
2.57394	2.52409	1.66426
2.57428	2.52144	1.662
2.57462	2.51612	1.66007
2.57496	2.5091	1.65827
2.57531	2.50039	1.6555
2.57565	2.49051	1.6514
2.57599	2.48024	1.64506
2.57634	2.47013	1.63658
2.57668	2.46248	1.62397
2.57702	2.46166	1.61217
2.57736	2.46263	1.60537
2.57771	2.46381	1.60199
2.57805	2.46223	1.60306
2.57839	2.45606	1.60379
2.57874	2.44826	1.6031
2.57908	2.43898	1.60105
2.57942	2.42926	1.59743
2.57977	2.4192	1.59283
2.58011	2.40791	1.5868
2.58045	2.39675	1.57679
2.5808	2.38927	1.56453
2.58114	2.38496	1.55191
2.58148	2.38564	1.54112
2.58182	2.38678	1.53672
2.58217	2.38432	1.53461
2.58251	2.37874	1.53374
2.58285	2.36835	1.53042
2.5832	2.35754	1.52264
2.58354	2.34666	1.5102
2.58388	2.34291	1.49183
2.58423	2.34786	1.47848
2.58457	2.35341	1.47116
2.58491	2.35896	1.46912
2.58525	2.35933	1.4717
2.5856	2.35493	1.47354
2.58594	2.34694	1.47404
2.58628	2.33658	1.47111
2.58663	2.32477	1.46452
2.58697	2.31502	1.45125
2.58731	2.31267	1.43704
2.58766	2.31352	1.42575
2.588	2.31731	1.41787
2.58834	2.3191	1.41586
2.58869	2.31605	1.41352
2.58903	2.31229	1.40915
2.58937	2.30828	1.40353
2.58971	2.30604	1.39646
2.59006	2.30582	1.39146
2.5904	2.30427	1.38857
2.59074	2.30134	1.38622
2.59109	2.29623	1.384
2.59143	2.28961	1.37989
2.59177	2.28254	1.37408
2.59211	2.27618	1.36528
2.59246	2.27361	1.35597
2.5928	2.27238	1.34896
2.59314	2.27222	1.34425
2.59349	2.26861	1.34509
2.59383	2.25611	1.34302
2.59417	2.24221	1.33373
2.59452	2.22719	1.31658
2.59486	2.22311	1.2879
2.5952	2.23499	1.26626
2.59555	2.24724	1.25534
2.59589	2.25865	1.2489
2.59623	2.26741	1.24738
2.59658	2.27283	1.24723
2.59692	2.2756	1.24813
2.59726	2.27575	1.24839
2.5976	2.27445	1.24781
2.59795	2.27213	1.24576
2.59829	2.27026	1.2428
2.59863	2.26836	1.23999
2.59898	2.26597	1.23701
2.59932	2.26325	1.23369
2.59966	2.26034	1.23012
2.6	2.25692	1.22658

Table. 2. The optical constants n and k with the corresponding wavelength in the visible region

λ[μm]	n	k
0.492718	3.9754	0.001177
0.492749	3.97189	0.003047
0.492872	3.98811	0.021072
0.492903	3.96649	0.013211
0.492934	3.97182	0.00182
0.492965	3.97336	0.003747
0.492996	3.97431	0.003469
0.493027	3.96805	0.006071
0.49315	3.99338	0.007852
0.493181	3.98505	0.011691
0.493212	3.97625	0.013601
0.493243	3.96599	0.002009
0.493366	4.00372	0.003097
0.493397	3.99653	0.014243
0.493428	3.99453	0.013016
0.493459	3.9949	0.022493
0.49349	3.98085	0.027511
0.493521	3.97045	0.016364
0.493551	3.97702	0.003125
0.493582	3.9901	0.006593
0.493613	3.99019	0.016291
0.493644	3.98684	0.021239
0.493675	3.98	0.024654
0.493706	3.97316	0.02285
0.493737	3.96641	0.017878
0.493768	3.9656	0.007683
0.493798	3.97012	0.001709
0.493922	4.00539	0.009323
0.493953	3.99581	0.022108
0.493984	3.98953	0.019424
0.494014	3.99251	0.023695
0.494045	3.98097	0.032292
0.494076	3.96711	0.019551
0.494107	3.97817	0.00149
0.494138	4.00113	0.011887
0.494169	3.99127	0.037211
0.4942	3.97184	0.031209
0.49423	3.97232	0.024823
0.494261	3.96743	0.024398
0.494292	3.96194	0.018088
0.494323	3.96098	0.00575
0.494385	3.98577	0.00593
0.494416	3.98173	0.017194
0.494447	3.9679	0.017199
0.494601	3.99933	0.005361
0.494632	3.99138	0.012085
0.494663	3.99532	0.005407
0.494693	4.00466	0.01716
0.494724	3.99265	0.030014
0.494755	3.98104	0.023493
0.494786	3.98047	0.01849
0.494817	3.97759	0.013035
0.494848	3.98238	0.006032
0.494879	3.98587	0.004399
0.49494	4.01471	0.005068
0.494971	4.01433	0.028745
0.495002	4.00095	0.039417
0.495033	3.98398	0.044241
0.495064	3.96132	0.030361
0.495156	4.01908	0.013816
0.495187	4.00416	0.022334
0.495218	4.01084	0.015769
0.495249	4.0234	0.029769
0.49528	4.01828	0.052154
0.495311	3.99796	0.06452
0.495342	3.97478	0.059239
0.495372	3.96506	0.038268
0.495403	3.97785	0.022298
0.495434	3.99498	0.029502
0.495465	3.99086	0.047419
0.495496	3.97625	0.04807
0.495527	3.97114	0.045405
0.495558	3.95848	0.043401
0.495589	3.94791	0.023106
0.49565	3.99628	0.006032
0.495681	3.99451	0.034519
0.495712	3.97576	0.037307
0.495743	3.96655	0.029267
0.495774	3.966	0.01291
0.495805	3.98555	0.007744
0.495835	3.99051	0.024523
0.495866	3.97947	0.025823
0.495897	3.98311	0.019424
0.495928	3.98655	0.027396
0.495959	3.97735	0.028537
0.49599	3.97699	0.022378
0.496021	3.97928	0.019599
0.496052	3.98782	0.023115
0.496082	3.97736	0.038592
0.496113	3.95753	0.022657
0.496144	3.97276	0.004775
0.496175	3.98161	0.01865
0.496206	3.96296	0.018751
0.496329	4.00277	0.005455
0.49636	4.01005	0.000415
0.496391	4.02171	0.017792
0.496422	4.01029	0.034007
0.496453	3.99467	0.035649
0.496484	3.98273	0.023966
0.496514	3.98675	0.005835
0.496576	4.02916	0.011181
0.496607	4.02669	0.03911
0.496638	4.00432	0.043815
0.496669	4.00375	0.031181
0.4967	4.01026	0.039726
0.496731	3.99865	0.043784
0.496761	3.99765	0.036157
0.496792	4.00223	0.040008
0.496823	3.99561	0.047036
0.496854	3.98352	0.043276
0.496885	3.97975	0.027937
0.496916	3.99479	0.016189
0.496947	4.0109	0.027424
0.496977	4.00643	0.04224
0.497008	3.99811	0.046486
0.497039	3.98372	0.047376
0.49707	3.97414	0.021874
0.497101	4.00871	0.006535
0.497132	4.02538	0.042886
0.497163	3.99671	0.057668
0.497194	3.98376	0.039927
0.497224	3.99344	0.027279
0.497255	4.00726	0.030437
0.497286	4.01204	0.045368
0.497317	3.99799	0.057065
0.497348	3.98438	0.046525

λ[µm]	n	k
0.497379	3.98997	0.034247
0.49741	4.00211	0.034732
0.49744	4.00617	0.046988
0.497471	3.99841	0.053572
0.497502	3.99367	0.053693
0.497533	3.99077	0.055584
0.497564	3.98127	0.059342
0.497595	3.96826	0.046309
0.497626	3.98007	0.031093
0.497657	3.98955	0.040419
0.497687	3.98278	0.044194
0.497718	3.97883	0.042699
0.497749	3.97116	0.036228
0.49778	3.97551	0.020229
0.497811	3.99265	0.017084
0.497842	4.00245	0.028277
0.497873	3.99696	0.038772
0.497903	3.99022	0.032374
0.497934	4.00315	0.028777
0.497965	4.00657	0.047865
0.497996	3.98609	0.053322
0.498027	3.97726	0.035604
0.498058	3.99029	0.023485
0.498089	4.00263	0.029808
0.498119	4.00551	0.037222
0.49815	4.00575	0.048078
0.498181	3.99498	0.053179
0.498212	3.99096	0.052049
0.498243	3.98169	0.053434
0.498274	3.975	0.043842
0.498305	3.97495	0.036383
0.498336	3.97679	0.02817
0.498366	3.98286	0.021241
0.498397	3.99499	0.01838
0.498428	4.00429	0.028713
0.498459	3.99888	0.038826
0.49849	3.9903	0.035161
0.498521	3.9968	0.028521
0.498552	4.00027	0.039509
0.498582	3.9859	0.039873
0.498613	3.98592	0.02523
0.498644	3.99519	0.025647
0.498675	3.98825	0.025277
0.498706	3.99366	0.006463
0.498737	4.01964	0.005921
0.498768	4.02964	0.025833
0.498799	4.02501	0.034777
0.498829	4.0296	0.042395
0.49886	4.01993	0.059196
0.498891	4.0043	0.054625
0.498922	4.00437	0.050056
0.498953	3.99991	0.050529
0.498984	3.99639	0.046061
0.499015	3.99345	0.042683
0.499045	3.9903	0.031091
0.499076	4.00527	0.018365
0.499107	4.02438	0.029381
0.499138	4.01998	0.050552
0.499169	3.99615	0.050339
0.4992	3.99163	0.021566
0.499231	4.02043	0.006213
0.499261	4.04737	0.022635
0.499292	4.05058	0.048304
0.499323	4.04144	0.063261
0.499354	4.03066	0.070377
0.499385	4.02121	0.071861
0.499416	4.01223	0.06817
0.499447	4.01614	0.059068
0.499478	4.02496	0.069937
0.499508	4.01263	0.081372
0.499539	4.00124	0.079094
0.49957	3.99009	0.0757
0.499601	3.98219	0.057925
0.499632	3.99882	0.045472
0.499663	4.00616	0.058799
0.499694	3.9943	0.059081
0.499724	3.99491	0.046524
0.499755	4.00848	0.043085
0.499786	4.01464	0.056107
0.499817	4.00408	0.062033
0.499848	3.99711	0.055357
0.499879	3.99776	0.04384
0.49991	4.01351	0.035339
0.499941	4.03133	0.050092
0.499971	4.02272	0.070955
0.500002	4.00774	0.068635
0.500033	4.00881	0.063617
0.500064	4.00702	0.069107
0.500095	3.99659	0.067125
0.500126	3.99368	0.058672
0.500157	3.9903	0.051007
0.500187	3.99547	0.03253
0.500218	4.02034	0.024985
0.500249	4.04274	0.041912
0.50028	4.04064	0.06657
0.500311	4.03185	0.072853
0.500342	4.02984	0.086395
0.500373	4.00404	0.095956
0.500404	3.98508	0.072571
0.500434	3.99959	0.05114
0.500465	4.01811	0.05827
0.500496	4.01635	0.072304
0.500527	4.0068	0.076635
0.500558	3.99517	0.072866
0.500589	3.99131	0.055083
0.50062	4.01066	0.044496
0.50065	4.02309	0.058878
0.500681	4.01826	0.067953
0.500712	4.0141	0.071527
0.500743	4.00779	0.071011
0.500774	4.00647	0.067828
0.500805	4.00329	0.067341
0.500836	3.9988	0.058599
0.500866	4.00763	0.047869
0.500897	4.01775	0.05042
0.500928	4.02057	0.04927
0.500959	4.03474	0.046925
0.50099	4.05175	0.062208
0.501021	4.04943	0.090369
0.501052	4.02317	0.10323
0.501083	4.00377	0.087056
0.501113	4.0118	0.068456
0.501144	4.02861	0.071707
0.501175	4.03177	0.085282
0.501206	4.02803	0.095871
0.501237	4.01606	0.107203
0.501268	3.99385	0.102814
0.501299	3.98743	0.080383
0.501329	4.00295	0.067362
0.50136	4.01643	0.076234
0.501391	4.01137	0.086627
0.501422	4.00481	0.084484

λ[µm]	n	k
0.501453	4.00443	0.08136
0.501484	4.00501	0.081153
0.501515	4.00132	0.081488
0.501546	3.99743	0.073077
0.501576	4.00681	0.063617
0.501607	4.01739	0.068302
0.501638	4.02078	0.070864
0.501669	4.0298	0.081189
0.5017	4.01644	0.093298
0.501731	4.01321	0.079831
0.501762	4.02675	0.086883
0.501792	4.01971	0.100409
0.501823	4.00867	0.102573
0.501854	3.99923	0.096736
0.501885	4.00074	0.088291
0.501916	4.00381	0.089282
0.501947	4.00225	0.089295
0.501978	4.00108	0.091363
0.502008	3.99114	0.088006
0.502039	3.99378	0.072444
0.50207	4.0071	0.071252
0.502101	4.01069	0.075998
0.502132	4.0141	0.075515
0.502163	4.02436	0.081719
0.502194	4.02075	0.100461
0.502225	4.00073	0.102313
0.502255	3.99342	0.087322
0.502286	4.00147	0.077453
0.502317	4.00992	0.079699
0.502348	4.01061	0.085191
0.502379	4.00568	0.085273
0.50241	4.00719	0.077686
0.502441	4.01736	0.077449
0.502471	4.02224	0.087489
0.502502	4.01322	0.093643
0.502533	4.01235	0.083498
0.502564	4.02486	0.089128
0.502595	4.01802	0.101154
0.502626	4.00996	0.097191
0.502657	4.01311	0.092051
0.502688	4.01989	0.09751
0.502718	4.01375	0.107867
0.502749	4.004	0.105745
0.50278	3.99979	0.103556

λ[µm]	n	k
0.502811	3.99056	0.095151
0.502842	3.99817	0.076534
0.502873	4.01937	0.078468
0.502904	4.02429	0.093706
0.502934	4.02086	0.100899
0.502965	4.01861	0.108724
0.502996	4.00656	0.114243
0.503027	3.99794	0.106855
0.503058	3.99647	0.103348
0.503089	3.98962	0.096913
0.50312	3.99153	0.08203
0.503151	4.00412	0.07176
0.503181	4.02547	0.069646
0.503212	4.04582	0.092368
0.503243	4.03199	0.120682
0.503274	4.00963	0.118113
0.503305	4.00663	0.104892
0.503336	4.01846	0.101868
0.503367	4.02157	0.118055
0.503397	4.00555	0.123273
0.503428	3.99974	0.115798
0.503459	3.99606	0.113883
0.50349	3.99197	0.10309
0.503521	4.00366	0.095299
0.503552	4.01075	0.102487
0.503583	4.01035	0.104713
0.503613	4.01564	0.10713
0.503644	4.0188	0.118603
0.503675	4.00783	0.131482
0.503706	3.99102	0.128112
0.503737	3.98736	0.117478
0.503768	3.98754	0.115394
0.503799	3.98094	0.108916
0.50383	3.98912	0.095345
0.50386	4.00345	0.105096
0.503891	3.98997	0.118345
0.503922	3.9743	0.102948
0.503953	3.98568	0.084075
0.503984	4.00133	0.088043
0.504015	4.00037	0.093722
0.504046	4.00271	0.08775
0.504076	4.01511	0.08939
0.504107	4.01902	0.100148
0.504138	4.01744	0.105216

λ[µm]	n	k
0.504169	4.01806	0.109506
0.5042	4.01826	0.115101
0.504231	4.01618	0.124767
0.504262	4.00193	0.132884
0.504293	3.98549	0.121721
0.504323	3.99019	0.103686
0.504354	4.00534	0.102503
0.504385	4.0105	0.113978
0.504416	4.00301	0.119627
0.504447	4.00125	0.116673
0.504478	4.00133	0.120493
0.504509	3.99426	0.121377
0.504539	3.99084	0.113759
0.50457	3.999	0.109701
0.504601	4.00144	0.119114
0.504632	3.99245	0.120592
0.504663	3.9898	0.115229
0.504694	3.98959	0.111026
0.504725	3.99399	0.105546
0.504755	4.00296	0.109151
0.504786	4.00046	0.11952
0.504817	3.98962	0.118864
0.504848	3.98755	0.106635
0.504879	4.0023	0.102157
0.50491	4.00776	0.11853
0.504941	3.99236	0.124224
0.504972	3.98574	0.111681
0.505002	3.99439	0.103635
0.505033	4.0026	0.106633
0.505064	4.00651	0.111947
0.505095	4.00747	0.120222
0.505126	4.00129	0.128514
0.505157	3.98919	0.130578
0.505188	3.97725	0.121946
0.505218	3.97633	0.103885
0.505249	3.99341	0.093628
0.50528	4.00615	0.103781
0.505311	4.00258	0.110668
0.505342	4.00543	0.106138
0.505373	4.01904	0.116403
0.505404	4.00759	0.139962
0.505435	3.98007	0.133726
0.505465	3.97802	0.10779
0.505496	4.00076	0.098888

λ[µm]	n	k
0.505527	4.01254	0.118373
0.505558	3.9976	0.12916
0.505589	3.99015	0.120437
0.50562	3.99235	0.117636
0.505651	3.99056	0.114916
0.505681	3.99423	0.110949
0.505712	3.99627	0.110652
0.505743	4.00204	0.107868
0.505774	4.00886	0.114636
0.505805	4.00763	0.121693
0.505836	4.00407	0.128149
0.505867	3.99352	0.129703
0.505897	3.98737	0.120518
0.505928	3.99102	0.111973
0.505959	3.99839	0.108748
0.50599	4.00525	0.111136
0.506021	4.01001	0.11446
0.506052	4.01553	0.126438
0.506083	3.99734	0.139665
0.506114	3.98025	0.117723
0.506144	4.00062	0.097804
0.506175	4.02198	0.109095
0.506206	4.02389	0.125357
0.506237	4.01984	0.135206
0.506268	4.01357	0.141637
0.506299	4.0068	0.146253
0.50633	3.99413	0.146403
0.50636	3.98865	0.133903
0.506391	3.99548	0.127652
0.506422	4.00081	0.128407
0.506453	4.00366	0.131384
0.506484	4.00708	0.133593
0.506515	4.01121	0.145095
0.506546	3.99745	0.159526
0.506577	3.97497	0.152741
0.506607	3.9707	0.130922
0.506638	3.9816	0.118796
0.506669	3.99584	0.112799
0.5067	4.01709	0.125208
0.506731	4.00746	0.152779
0.506762	3.98482	0.144278
0.506793	3.99556	0.132234
0.506823	3.99947	0.146745

λ[µm]	n	k
0.506854	3.98495	0.148895
0.506885	3.9813	0.140463
0.506916	3.98087	0.137659
0.506947	3.97906	0.131389
0.506978	3.98495	0.124053
0.507009	3.99539	0.125384
0.50704	3.99725	0.134948
0.50707	3.99167	0.134404
0.507101	3.99883	0.132277
0.507132	4.00216	0.1442
0.507163	3.99211	0.15282
0.507194	3.98086	0.149732
0.507225	3.97825	0.144631
0.507256	3.97129	0.143244
0.507286	3.96441	0.128611
0.507317	3.97555	0.112821
0.507348	3.99213	0.113826
0.507379	3.99685	0.120403
0.50741	4.00336	0.120458
0.507441	4.01365	0.132604
0.507472	4.00513	0.149809
0.507502	3.98739	0.147122
0.507533	3.9868	0.130488
0.507564	4.0044	0.126229
0.507595	4.01536	0.143278
0.507626	4.00562	0.159315
0.507657	3.99207	0.160965
0.507688	3.98413	0.155728
0.507719	3.98306	0.151328
0.507749	3.97932	0.151233
0.50778	3.97223	0.143749
0.507811	3.97461	0.128691
0.507842	3.99157	0.119666
0.507873	4.01066	0.128781
0.507904	4.01361	0.147981
0.507935	4.00618	0.155077
0.507965	4.00786	0.161489
0.507996	3.99872	0.17462
0.508027	3.98548	0.17478
0.508058	3.97715	0.173006
0.508089	3.96907	0.167162
0.50812	3.96856	0.16046
0.508151	3.96714	0.161715

λ[µm]	n	k
0.508182	3.95679	0.15636
0.508212	3.95786	0.141175
0.508243	3.96847	0.135695
0.508274	3.97509	0.139697
0.508305	3.97169	0.141456
0.508336	3.97395	0.13434
0.508367	3.9821	0.134033
0.508398	3.9885	0.137872
0.508428	3.99084	0.145255
0.508459	3.99051	0.151062
0.50849	3.98581	0.159138
0.508521	3.97498	0.158948
0.508552	3.97024	0.150193
0.508583	3.97584	0.142645
0.508614	3.98333	0.143414
0.508644	3.99067	0.147834
0.508675	3.99221	0.162048
0.508706	3.97912	0.170017
0.508737	3.96903	0.164727
0.508768	3.9684	0.158553
0.508799	3.9699	0.158076
0.50883	3.96891	0.160304
0.508861	3.96246	0.162015
0.508891	3.9554	0.155498
0.508922	3.95574	0.146055
0.508953	3.96243	0.140918
0.508984	3.96539	0.143136
0.509015	3.96419	0.137816
0.509046	3.97692	0.131899
0.509077	3.99041	0.146903
0.509107	3.97741	0.165056
0.509138	3.96037	0.155486
0.509169	3.96729	0.14291
0.5092	3.97518	0.148347
0.509231	3.97119	0.151122
0.509262	3.97497	0.148779
0.509293	3.97715	0.157894
0.509324	3.96866	0.162369
0.509354	3.96175	0.160728
0.509385	3.95601	0.154855
0.509416	3.95747	0.146964
0.509447	3.96153	0.144523
0.509478	3.96486	0.142509