STUDY OF TRANSPARENT FERROELECTRIC THIN FILMS BY OPTICAL REFLECTOMETRY AND ELLIPSOMETRY

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Motivation

Are investigated:

✓Dielectric and optical properties for ferroelectric bulk materials

✓Dielectric properties for ferroelectric thin films

Optical properties for ferroelectric thin films have been relatively rarely studied.

Ferrolectric thin films are used:

✓high dielectric constant capacitors

✓non-volatile memories

✓infrared sensors

✓electro-optic devices

Reflectometry

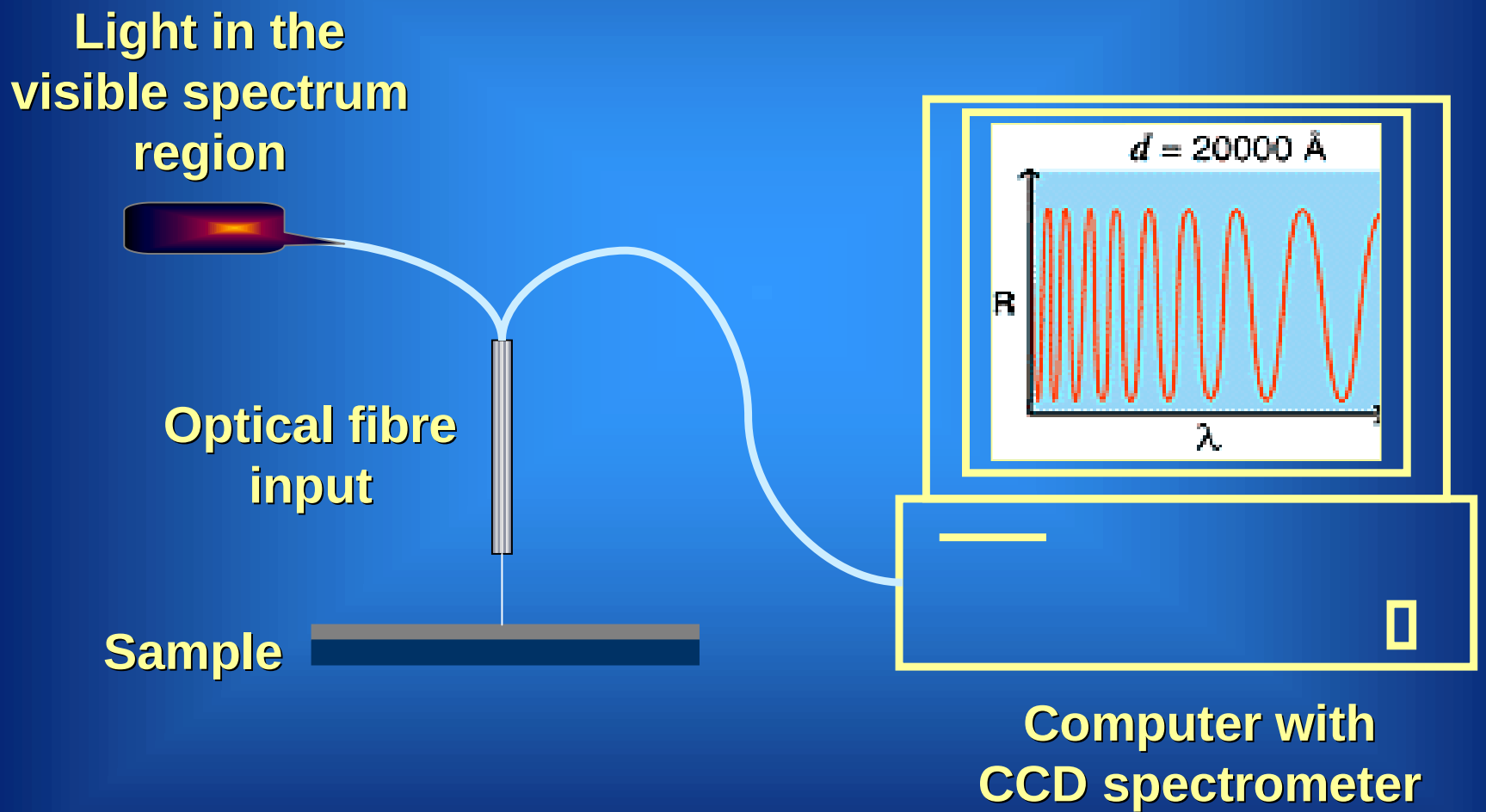
Reflective coefficient *R*

Ellipsometry

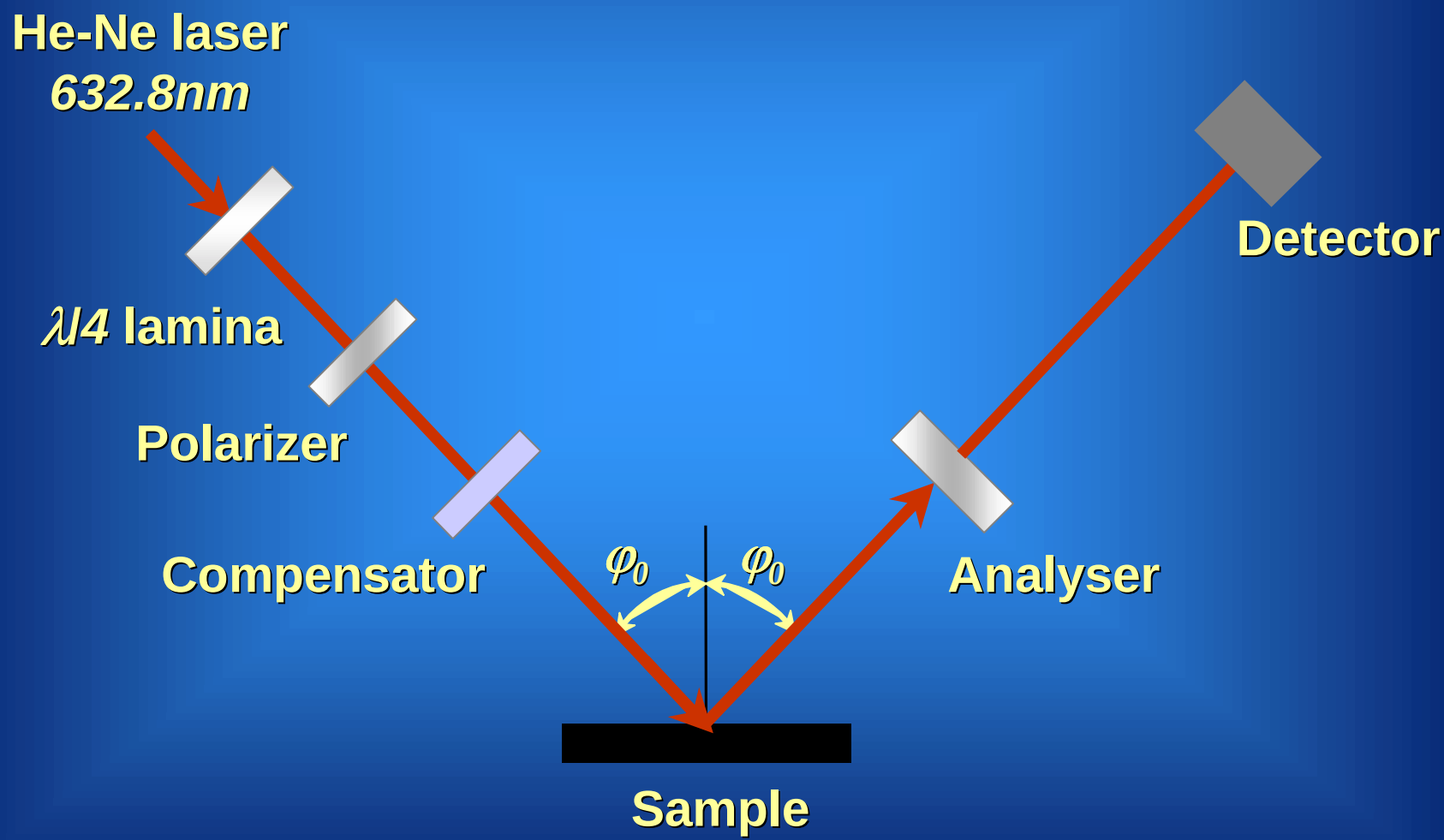
Main ellipsometric angles Ψ, Δ

Reflactive *n* and absorbtion *k* coefficients, thickness

Illustrative sham for reflectometry measurements



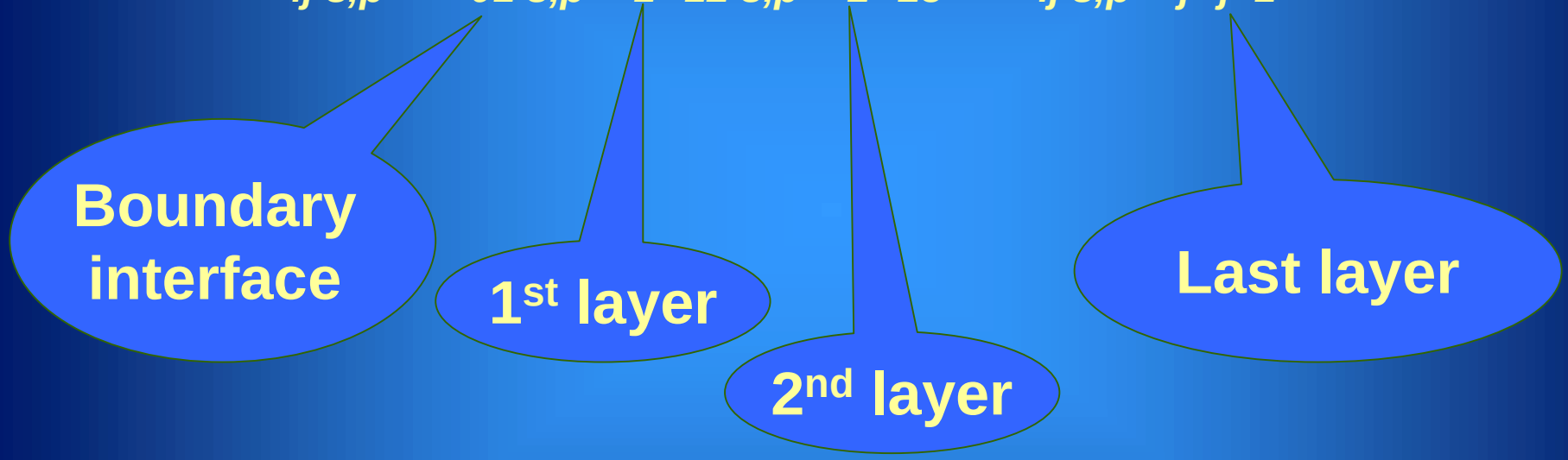
Ellipsometer sham



Multilayer model

Idea of the matrix method

$$M_{ij\ s,p} = I_{01\ s,p}\, L_1\, I_{12\ s,p}\, L_2\, I_{23} \ldots I_{ij\ s,p}\, L_j\, I_{j+1}$$



Reflective index:

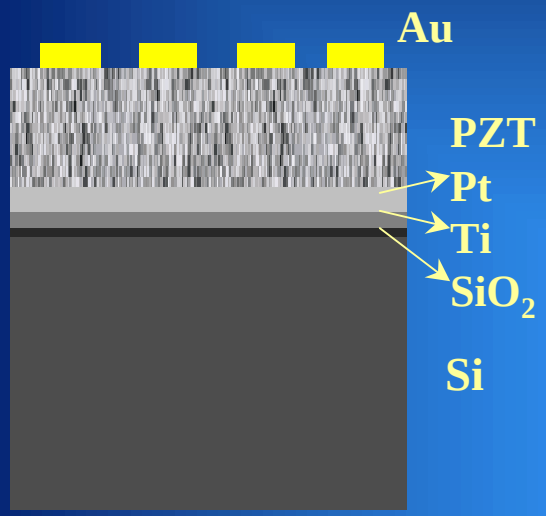
$$R_p = M_{21p} / M_{11p}$$
$$R_s = M_{21s} / M_{11s}$$

Ellipsometric formula:

$$tg\Psi\, e^{\Delta} = R_p / R_s$$

Mean square error $\Delta\Phi = \int (f_{exp} - f_{teor})^2$

Samples



- ✓$BaTiO_3$ BT derivation tech.: laser ablation [1)]
- ✓$Pb(Ti_{0,48}Zr_{0,52})O_3$ PZT sol-gel[2)], laser ablation
- ✓$Pb(Mg_{0.66}Ni_{0.34})O_3$ PMN rf sputtering[3)]

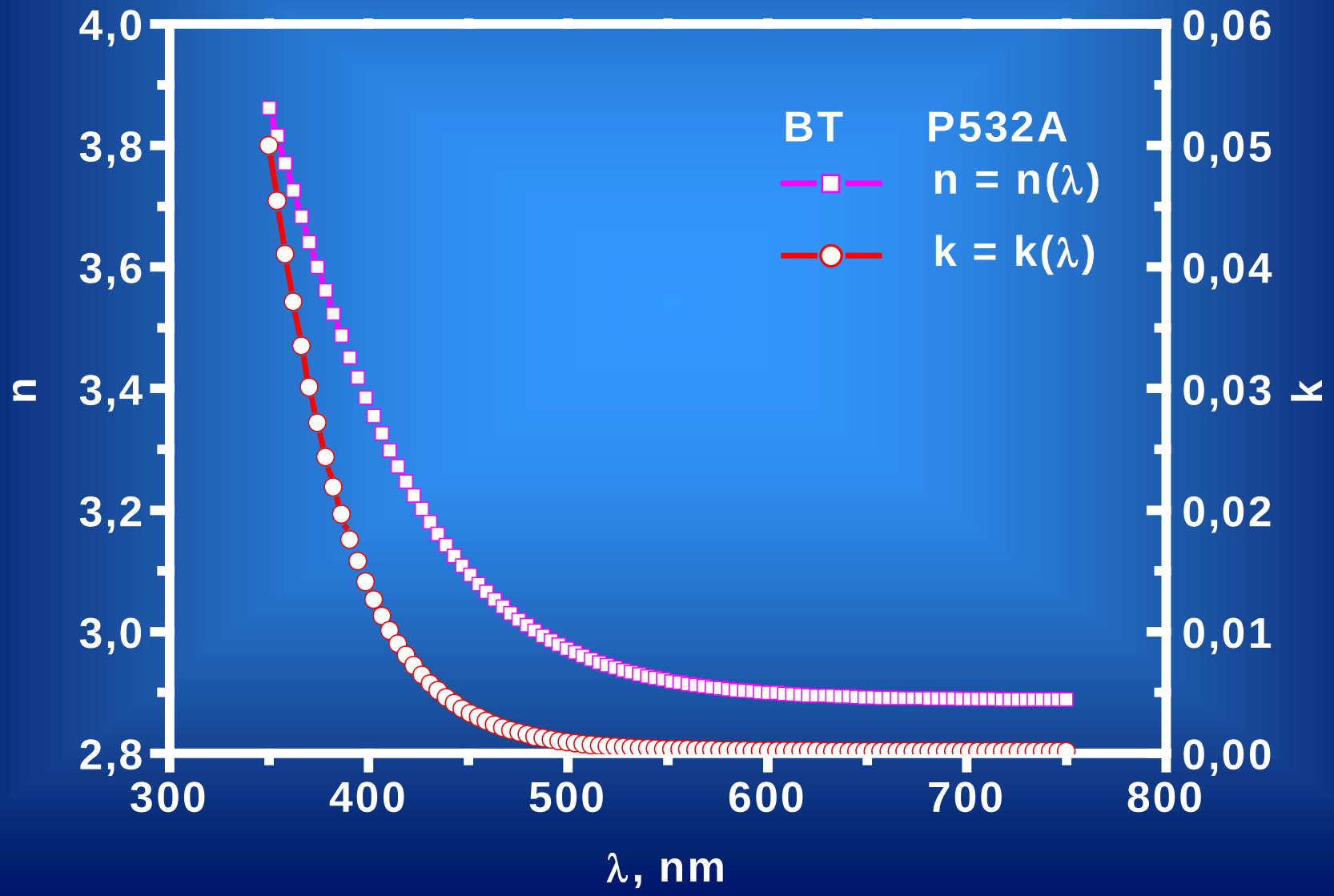
[1)] In collaboration with Solid state and material research institute in Dresden, IFM-Dresden, Germany

[2)] In collaboration with Yosef Stefan Institute in Slovenia

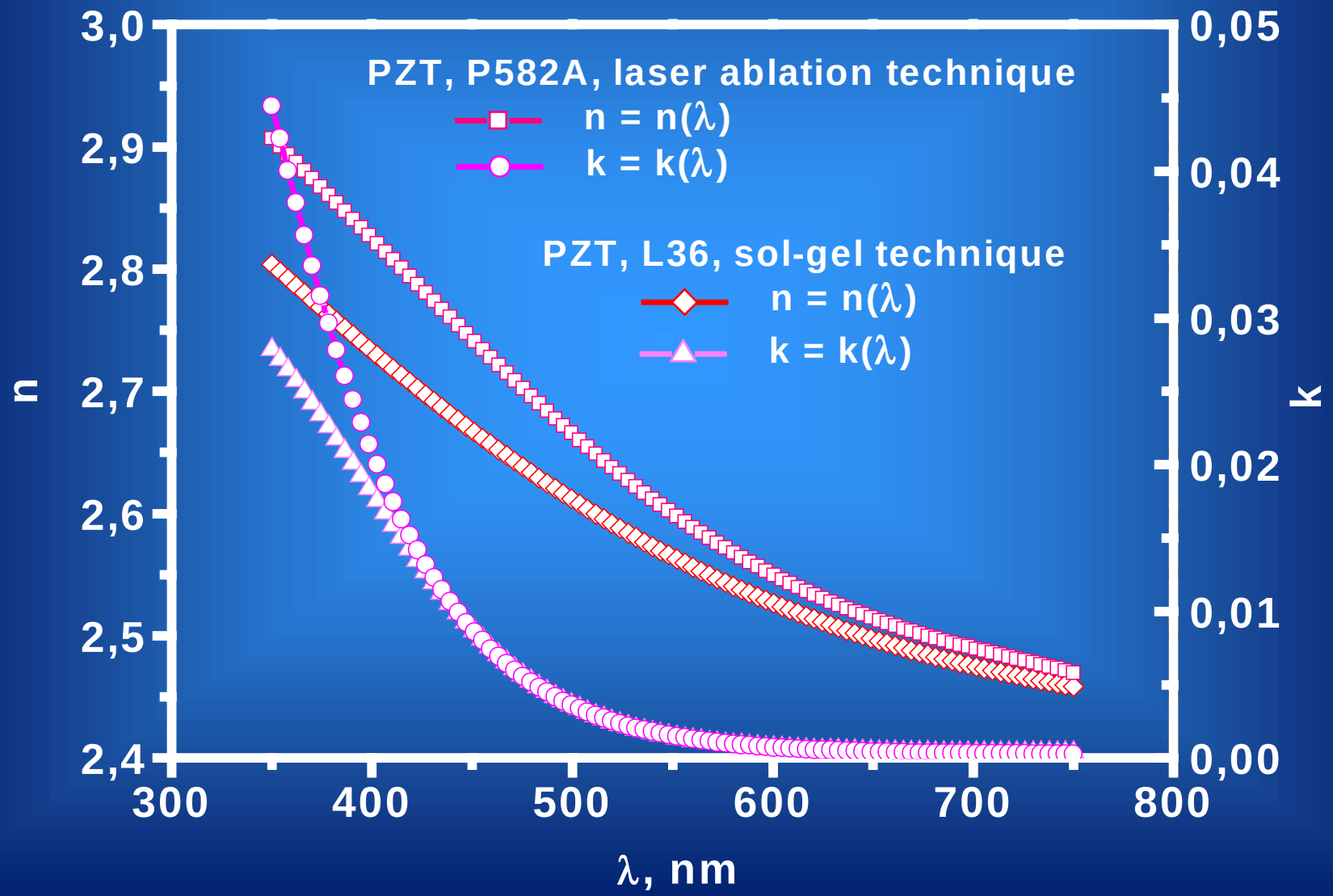
[3)] In collaboration with University of Sarland, Germany

Results

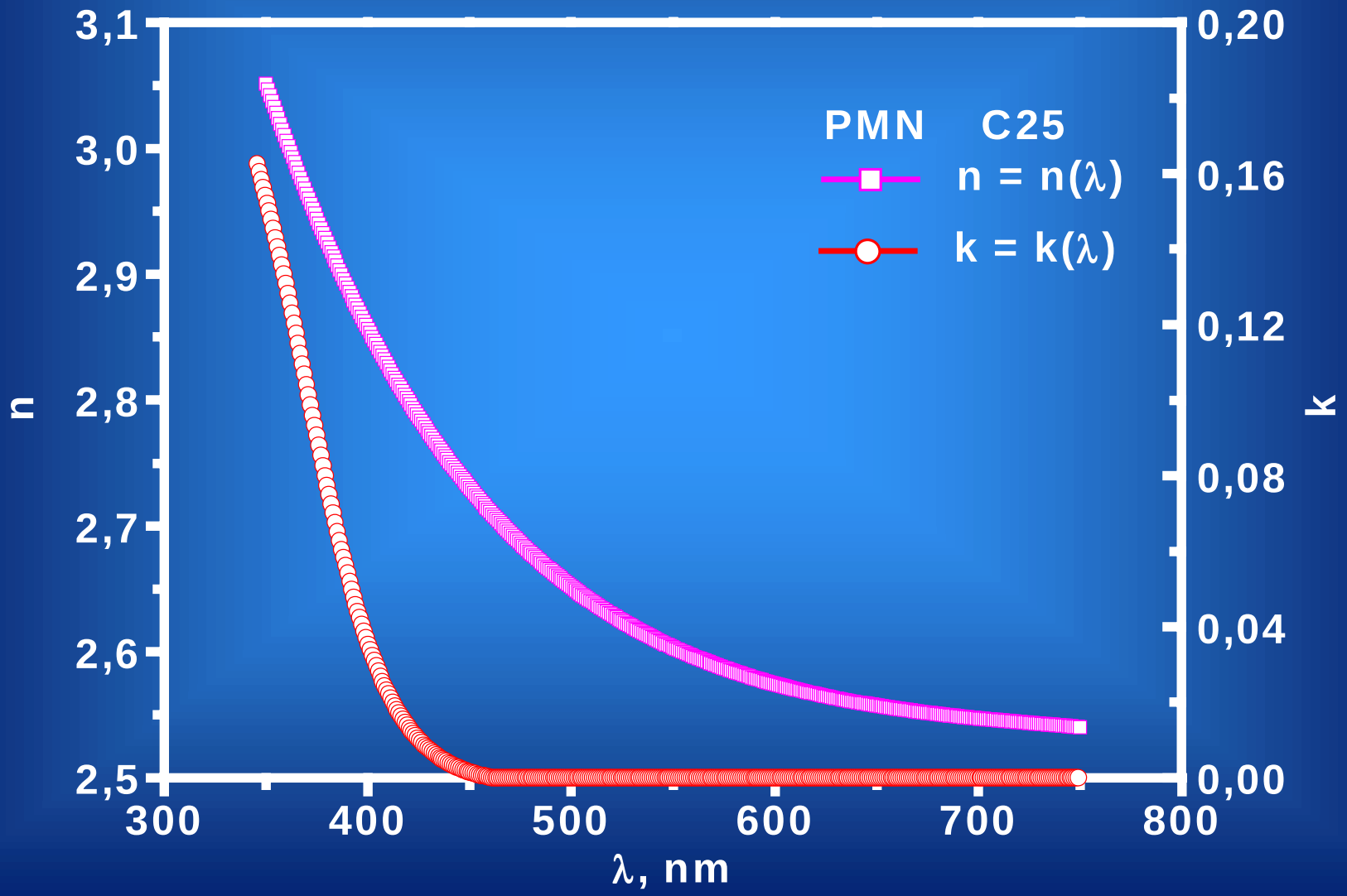
Refraction *n* and absorption *k* coefficients for BT thin film (thickness 340 ± 7nm as calculated from reflectometric data; sol-gel technique).



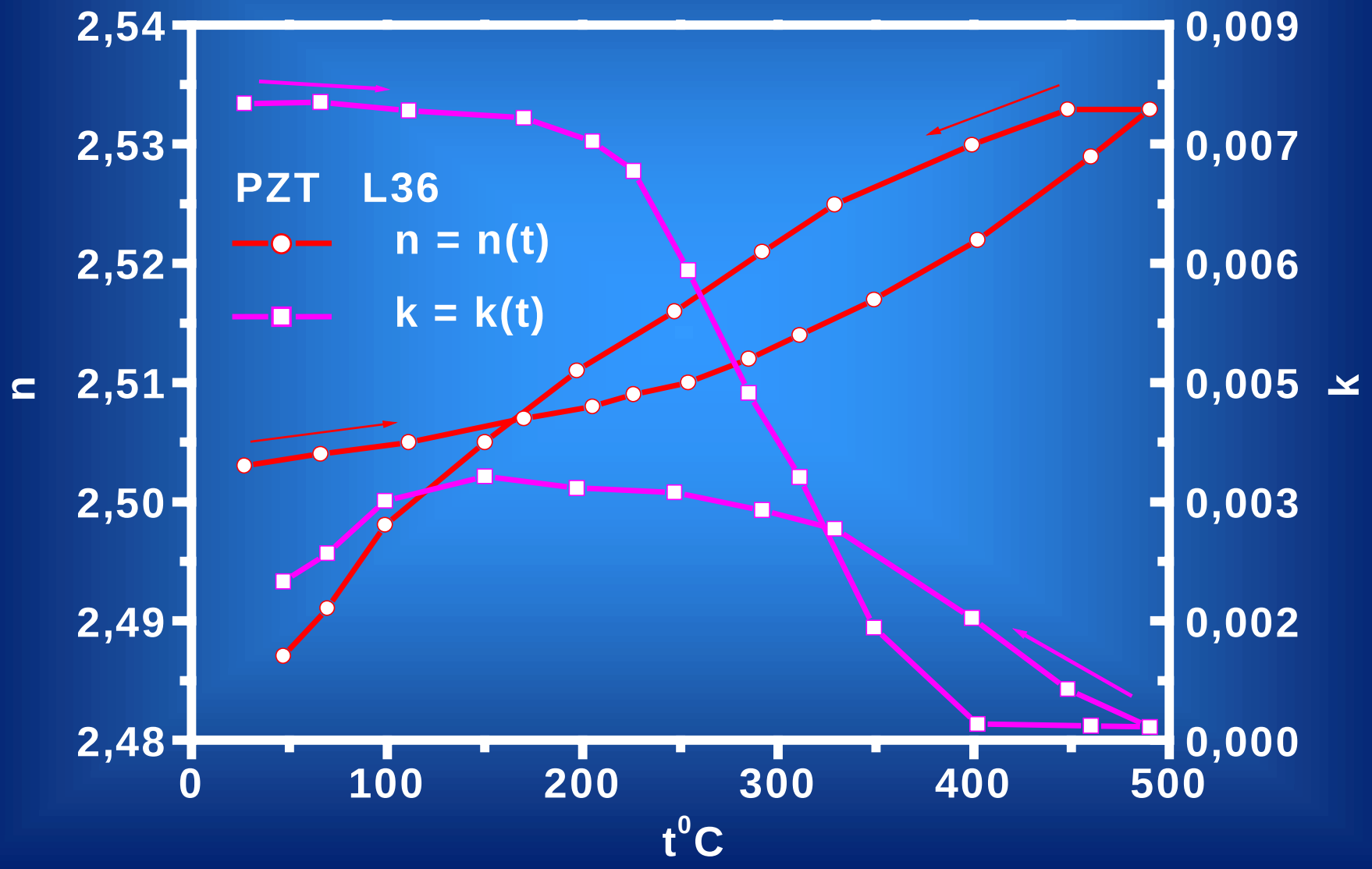
The refractive index *n* and extinction coefficient *k* of PZT deposited by laser ablation (thickness 250nm) and so-gel (thickness 300nm) technique.



Refraction *n* and absorption *k* coefficients for PMN thin film (thickness 770 ± 10nm, as calculated from reflectometric data laser ablation technique).



Temperature dependence of refractive *n* and absorption *k* indexes of PZT film (thickness 300nm) at wavelength 632,8nm. Temperature slowly raised at average rate 4°C/minute.



Conclusions

Ellipsometric and reflectometric measurements has been successfully applied for the thickness, refractive and absorption coefficient determination of BT, PZT, PMN thin films. Optical properties and thickness are well described by multilayer model.

Slight variation of refractive index by factor 1.02 and absorption coefficient by factor of 1.04 has been observed in comparison of sol-gel and laser ablation deposited samples, respectively.

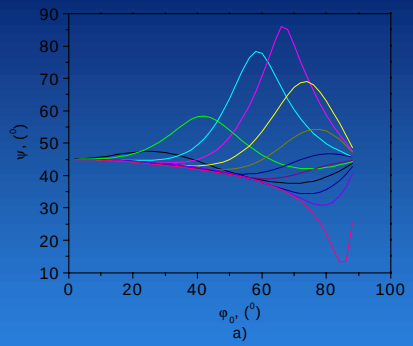
Observed temperature dependence of the refractive index and the absorption coefficient in the temperature range above 400°C is described by diffuse ferroelectric/paraelectric phase transition

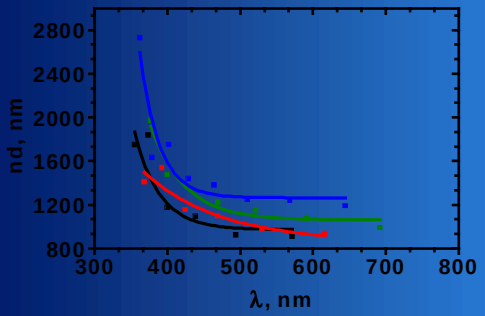
Ackowledgement

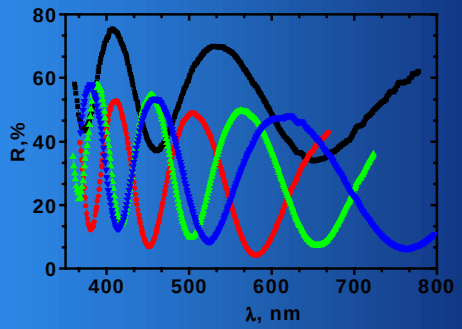
The author is thankful V.Zauls[1)], K.Kundzins[2)] for valuable discussions.

This work was supported by K.Morberg scholarship of Latvian University.

[1, 2)] Institute of Solid State Physics, University of Latvia







Thank you for attention !