INFRARED SPECTROSCOPIC METHODS AT CENTRAL EUROPEAN SYNCHROTRON LABORATORY

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Infrared spectroscopy is a powerful tool for characterizing the chemical composition, structure and infrared-active lattice and charge excitations. For example, ions vibrate at specific frequencies corresponding to their mass and bonds, thus each molecule has a characteristic profile over the infrared spectrum. Due to the broad scope and its non-destructive character, infrared spectroscopy is used in a wide range of applications including material research, surface science, geology, biological sciences, and nanoscience.

Infrared spectroscopy generally suffers from a lack of intense and highly collimated sources of radiation. For several applications like microscopy and ellipsometry, this represents a substantial restriction. A synchrotron delivers highly collimated and intensive infrared radiation that outperforms standard sources (globar and Hg-lamp) in brilliance by several orders of magnitude.

Currently, the Czech and European scientific community discusses an implementation of some of the following infrared techniques in an infrared beamline at Central European Synchrotron Laboratory: ellipsometry, imaging microscopy, reflection and transmission of small samples and spectroscopy under high pressures and high magnetic fields. Below, we present a brief overview of these techniques and their potential applications.

Ellipsometry is a technique that enables determination of both parts of the dielectric function corresponding to refraction and absorption, respectively, without using any other assumptions like Kramers-Kronig transformation and without the necessity of reference measurements. Due to these advantages, ellipsometry is recognized as delivering highly reliable data [1]. In the far- and mid-infrared range (8–5000 cm^{-1}, 1 meV–630 meV), this technique will be mostly appreciated for studies of conducting systems, for example, doped perovskites (high-temperature superconductors, manganites, titanites), semiconductors, and conducting polymers. Ellipsometry is also very beneficial for the analysis of multilayered structures.

Infrared imaging microscopy enables spatially resolved chemical analysis which is of great importance for highly inhomogeneous samples, e.g., biological material. The high brilliance of synchrotron infrared radiation enables to increase the spatial resolution by about two orders of magnitude down to the diffraction limit, ca 3×3 m^2 in the mid-infrared range. For more information, we refer to the Center of Sychrotron Biosciences (Case Western Reserve University, USA) [2].

Infrared spectroscopy under magnetic fields brings important information particularly about systems with strongly correlated electrons where spin interactions play a crucial role, like manganites, superconductors and magnetic materials. The combination of infrared ellipsometry with magnetic field is able to determine the effective mass of charge carriers [3]. For this purpose, the high brilliance of synchrotron radiation would be largely beneficial. Proposed methods: reflection, transmission and ellipsometry.

Infrared spectroscopy under high pressures brings additional information about the phase diagram and the interactions that determine the structure and electronic properties of the material [4]. The coupling of synchrotron infrared radiation to the diamond-anvil cell methods allows to measure up to the pressures of about 250 GPa. Second topic of the setup would be measurements of small samples by reflection or transmission. Since high quality crystals of new materials have usually small size, the measurements with well focused light are highly desirable. These methods will be particularly useful, among others, for studies of ferroelectrics and related materials like incipient ferroelectrics, and high-permittivity low-loss dielectrics.

References:

1. A.V. Boris, N.N. Kovaleva, O.V. Dolgov, T. Holden, C.T. Lin, B. Keimer, and C. Bernhard, *Science* **304**, 708 (2004).
2. http://casemed.case.edu/proteomics/CSB/infrared.shtml.
3. T. Hofmann, U. Schade, K.C. Agarwal, B. Daniel, C. Klingshirn, M. Hetterich, C.M. Herzinger, M. Schubert,, *Appl. Phys. Lett.* **88**, 042105 (2006).
4. A. Sacchetti, M. Cestelli Guidi, E. Arcangeletti, A. Nucara, P. Calvani, M. Piccinini, A. Marcelli and P. Postorino, *Phys. Rev. Lett.* **96**, 035503 (2006).