The offer of high tech services
complex optical and photoelectric sample analysis

1. **Ellipsometric characterization of samples in the vacuum UV range**
2. **Determination of MIS systems band diagrams using unique photoelectric methods**
3. **Determination of nanostructures chemical composition, temperature, stress and doping using Raman spectroscopy. Analysis of samples and devices under electrical bias**

Measurements methodology

Ellipsometry

We determine the optical properties of various materials (primarily semiconductors and dielectrics) and nanoelectronic structures by spectroscopic ellipsometry in the vacuum UV range. The spectral characteristics of the complex refractive index N(λ) and complex dielectric function ε(λ), where N=n+ik and $\varepsilon=\varepsilon_1+i\varepsilon_2$, are estimated, as well as thicknesses of layers constituting nanostructures. For these purposes two spectroscopic ellipsometers are used:

- The Vacuum Spectroscopic Phase Modulated Ellipsometer (UVISEL VUV) of Horiba Jobin-Yvon S.A.S., operating in the light wavelength range λ=(142-880) nm, with the constant light incidence angle of 70°, shown in Fig.1.
- The Variable Angle Spectroscopic Ellipsometer (VASE) of J.A. Woollam Co. Inc., operating in the light wavelength range λ=(250-1700) nm and in the light incidence angle range from 15 to 84 degrees, shown in Fig.2.

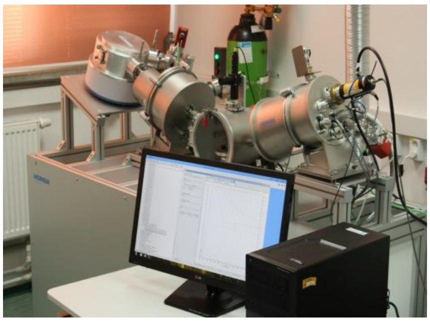

Fig.1 Scanning Spectroscopic Phase Modulated Ellipsometer (UVISEL VUV) Horiba Jobin-Yvon.

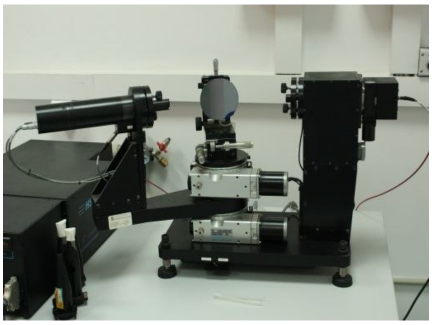

Fig.2 Variable Angle Spectroscopic Ellipsometer (VASE) J.A. Woollam Co. Inc.

Photoelectric measurements methodology

Photoelectric methods are used to determine the potential barrier heights at interfaces of various materials and other crucial electrical properties of nanoelectronic structures. This enables identification of energy levels and characteristic potentials allowing determination of complete energy band diagrams of investigated samples. An example of such a band diagram is shown in Fig.4 in which values of all the marked potentials were estimated. For this purpose both the standard photoelectric methods and a package of original and precise in-house developed methods are used which allow, among others, extremely accurate determination of the effective contact potential difference in the MIS system. These methods are also used for mapping the parameter distributions over certain areas, such as the barrier height distribution over the gate area of a MIS structure, shown in Fig.5.

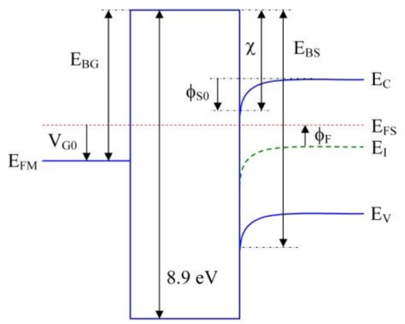

Fig.4 Example of the band diagram of a Al-SiO_2-SiC(3C) MIS structure. Values of all the marked potentials were determined.

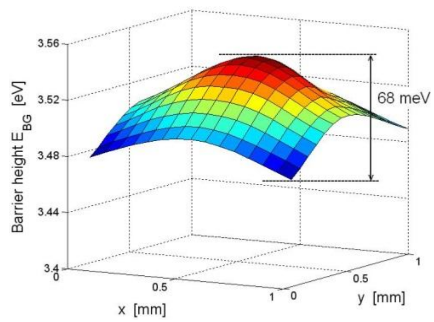

Fig.5 Two dimensional distribution of the gate-dielectric barrier height in a Al-SiO_2-Si MIS structure.

Measurements are made using primarily two advanced, in-house designed and built photoelectric measurement systems:

- The Multitasking Photoelectric Measurements System (WSBF), shown in Fig.6, allowing measurements of a number of photoelectric characteristics of nanoelectronic structures such as:
  - current I and photocurrent I_{ph} in function of light wavelength λ and voltage V;
  - capacitance C in function of λ and V;
  - the above characteristics in function of light beam power P.

  The WSBF system has won the title “Champion of Technology Warsaw-2001” granted by the Polish Federation of Technical Associations

- The Universal Photoelectric Measurements System (USBF), shown in Fig.7, which in addition to all the functions fulfilled by the WSBF system has an extended range of the light wavelengths (λ=160-900 nm), better definition of the light spot dimensions, the possibility of scanning the

- sample with the light spot, higher resolution of current measurement (10^{-16} A), control of light beam power distribution over the light spot and semiautomatic execution of measurements.
  The USBF system received recognition in the Polish nationwide competition "Champion of Technology–2012/2013" organized by the Polish Federation of Technical Associations.

Fig.6 The Multitasking Photoelectric Measurements System WSBF.

Fig.7 The Universal Photoelectric Measurements System USBF.

Raman spectroscopy. Analysis of samples and devices under electrical bias

Raman spectroscopy provides information on chemical structures, atomic bonds and physical forms of investigated samples. This measurement technique allows identification of several parameters of measured sample, such as: temperature, stress, doping concentration. These parameters can be mapped over the sample and/or the depth profile of the parameters can be taken. We can also analyze the behavior of these parameters in materials and devices under electrical bias. Samples can be examined in different physical states: solid, liquid and vapor. Additionally, the experiments can be performed at temperatures below 0°C using the cooling system with liquid nitrogen.

Measurements are made using Raman system (Fig.8) equipped with MonoVista Micro-Raman Spectrometer (Spectroscopy and Imaging GmbH Germany) with JAI imaging camera and CCD detection camera, argon laser with wavelength λ = 488 nm, Nd-Yag (CryLas GmbH, Germany) for measurement at wavelength λ = 266 nm.

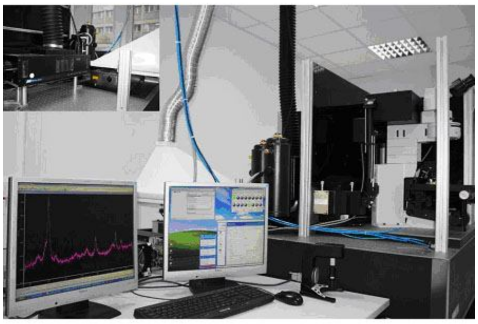

Fig.8 MonoVista Micro-Raman Spectrometer.

<u>For photoelectric measurements customer should agree the sample preparation method.</u>

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