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NANOSCALE OPTICAL ABSORPTION AND PHOTOTHERMAL EXPANSION OF THE NOVEL TWO-DIMENSIONAL $Zn_2In_2S_5$ BY NANO-VIS

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Modern technologies have already reached the limits of electronics in terms of performance and size. Nevertheless, the necessity of increasing the capacity of the device turns into integrating photonics that implies complexity increase. One of the key parts in photonic devices are photodetectors that allow the transformation of optical signals to electrical ones. This transduction results in heating of the device. This is why the preliminary testing of material's properties, e.g. photothermal expansion and absorption at the nanoscale is essential. However, until now, analyzing optical or thermal properties at the nanoscale is a persistent technological challenge in nanoanalysis. While optical spectroscopy is limited by the diffraction limit of light, thermal properties spatial resolution analysis is limited by the size of the thermal probe such as a thermometer or thermal cameras that are also limited by diffraction of light and optics.

Atomic force microscopy (AFM) as a powerful tool for comprehensive study of materials properties allows also developing new nanoscale analysis techniques. Herein, *nano-vis* is the method of photothermal expansion measure using continuous wave lasers and AFM tip in tandem[1]. With this method, we aimed at a novel two-dimensional crystal material $Zn_2In_2S_5$ and examined its photothermal expansion at the nanoscale.

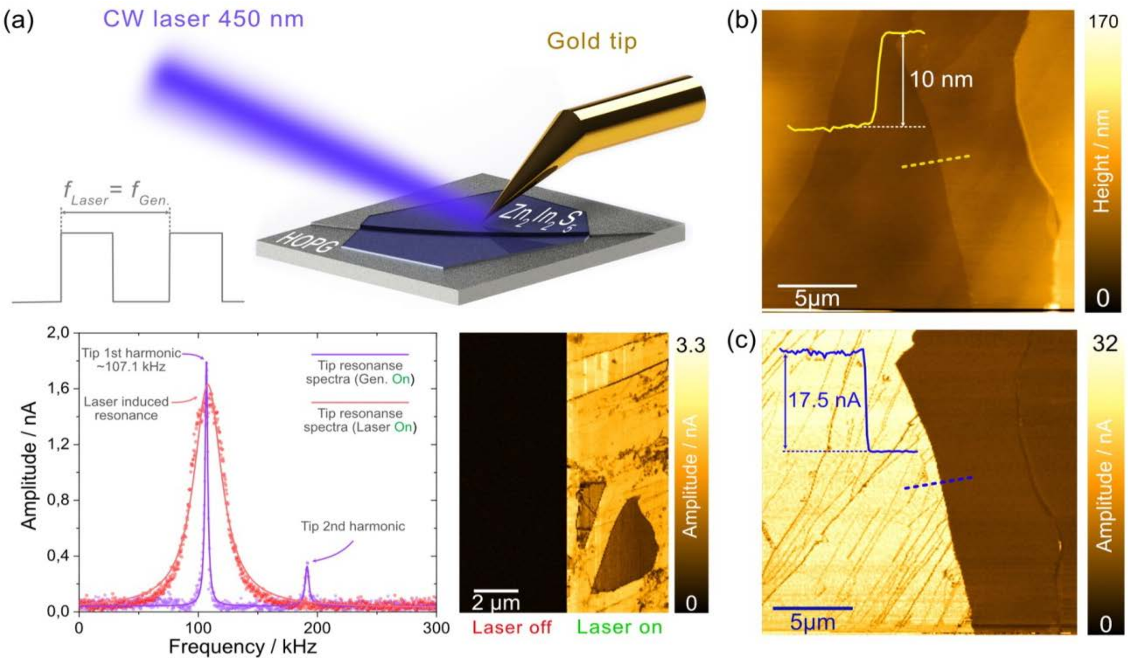

Figure 1 – (a) Scheme explaining the principle of nano-vis. Plot represents the way of tip oscillation induced by the continuous laser and contact AFM amplitude image while the laser was on and off. (b) AFM topography covering the region of interest and (c) amplitude signal representing photothermal expansion of the material $Zn_2In_2S_5$.

In the experiment we used a 450 nm laser excitation, which is close to the 2.7 eV band gap of the material inducing a photon-electronic resonant absorption process. Also, we used gold tip as a confined light source and for inducing localized surface plasmons that help to improve signal quality. Generally, gold tip is a standard component in tip-enhanced Raman spectroscopy technique. Achieving plasmon resonance conditions it is possible to enhance an optical signal up to 10^6 times [2]. Hence, heating of a sample takes place and is caused by two factors: resonant absorption of light and localized hot electrons. Figure 1b demonstrates a topography image with a 10 nm thickness flake. Photothermal effects can be seen in fig. 2c, where the lowering of signal over the material may refer to $Zn_2In_2S_5$ less absorbance at 450 nm wavelength irradiation in comparison with HOPG. Instead, the material seems to be reflectable at a current wavelength since the amplitude of the cantilever decreased, i.e $Zn_2In_2S_5$ express less photothermal expansion than HOPG. For next investigations we're planning to apply lasers with different wavelengths to demonstrate light-matter interaction and photothermal properties of the material.

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