Scanning near-field optoacoustic microscopy

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Background, Motivation and Objective

Optoacoustic (or photoacoustic) microscopy technology has been widely used for material non-destructive testing. Its spatial resolution is limited by either optical or acoustic diffraction limit, depending on the focusing mechanism involved. Driven by the desire for imaging and detecting of materiel structures and properties on the nanometer scale, optoacoustic microscopy could potentially be realized via a near-field scanning optical microscope (NSOM) using a nano-aperture probe.

Statement of Contribution/Methods

In this work, we proposed and developed a Near-Field Scanning Optoacoustic Microscope (NSOAM) system. A nano-second pulsed laser working at a wavelength of 532 nm is used to replace the original continuous-wave laser source in a commercial NSOM system. The laser beam was focused, with a beam size of 50 nm in diameter, on the surface of the sample through the tip aperture of a NSOM probe. A custom-designed high-frequency broadband ultrasound transducer was placed under the sample to receive the optoacoustic signal. Two-dimensional raster scan was conducted with a maximal scanning area of 100 μm ×100 μm.

Results/Discussion

The sample used was a trial-made metal-semiconductor chip. There were some tungsten patterns on the SiGe layer coated on the silicon substrate. Both tungsten and SiGe can generate detectable optoacoustic signals when illuminated by the 532-nm laser pulse. Due to the difference in energy conversion mechanism between the light-metal and the light-semiconductor interactions, the optoacoustic signals from tungsten and SiGe had different characteristics. By extracting the parameters of the optoacoustic signal waveforms, the tungsten pattern on the SiGe layer was mapped successfully, with a spatial resolution better than 35 nm. In addition, we also studied different photo-generated carrier lifetime of SiGe based on the electronic volume effect under both near-field and far-field pulsed laser illumination. This helped to understand the difference between two-dimensional and three-dimensional carrier transportation.

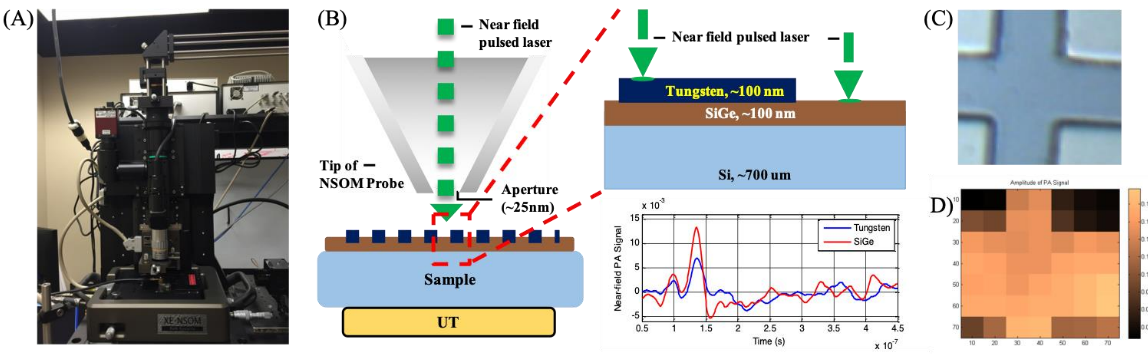

Fig.1. (A) Photograph of our SNOAM system; (B) Schematic showing the pulsed laser with 50-nm diameter beam size radiating on the sample, producing optoacoustic signals which are detected in near-field by a high-frequency ultrasound transducer (UT) on the other side of the sample. The sample structure and the example optoacoustic signals are also shown. (C) An enlarged photo of the sample; (D) The near-field optoacoustic image of the structure shown in (C).