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Characterization of Gold thin film by Parallel Plate Waveguide Terahertz – Time Domain Spectroscopy

R. Manjakavahoaka, R. Kinjo, K. Takayama, I. Kawayama, H. Murakami, and M. Tonouchi
Institute of Laser Engineering, Osaka University
2-6 Yamadaoka, Suita, Osaka 565-0871, Japan
E-mail: razanoelina@ile.osaka-u.ac.jp

Over the past few years, many groups intensively investigated on Parallel Plate Waveguide (PPWG) for sensing and THz wave guiding. PPWG was used as THz microfluidic sensing by exploiting its fundamental transverse electric (TE) mode. In other group, THZ characterization of Zinc Oxide nanowire was done using PPWG. Recently, it has been shown that the conductivity of aluminum deposited on polished silicon wafer in PPWG increases at 77K.

Despite the number of applications with THz PPWG, characterization of high conductive metal in their nanostructure states has not been yet realized. We exploit the long path interaction of THz wave with materials inside the guide to characterize nano layer of gold (Au) on insulator substrate. The purpose of this work is to describe the THz response of Au in the insulator metal transition (IMT) states using the two polarizations mode inside a PPWG.

The THz conductivity of Au recently reported shows that with layer thickness below 6nm, Au behaves like insulator and conductive above 8nm. In that paper, the gold was deposited on silicon wafer. For this research, Au nanostructures of different thicknesses were deposited on Magnesium Oxide substrate (MgO) by sputtering growing process. For layer thickness of 8nm, the atomic force microscope (AFM) scans shows formation of individual gold islands but connected to each other (Fig. 1a). The THz pulses of Au thicknesses 8nm and 1nm are shown in Fig. 1b. The Au nano film is inserted between two MgO plates and put together inside a PPWG. The reference pulse is MgO in a PPWG. In the frequency domain plot of 8nm of Au (Fig.1c), there is an obvious shift in the lower frequency cutoff which is due to the metal behavior of the Au nano layer. For 1nm Au (Fig. 1d), the spectrum overlaps exactly the reference spectrum, which means that the film is an insulator in THz range.

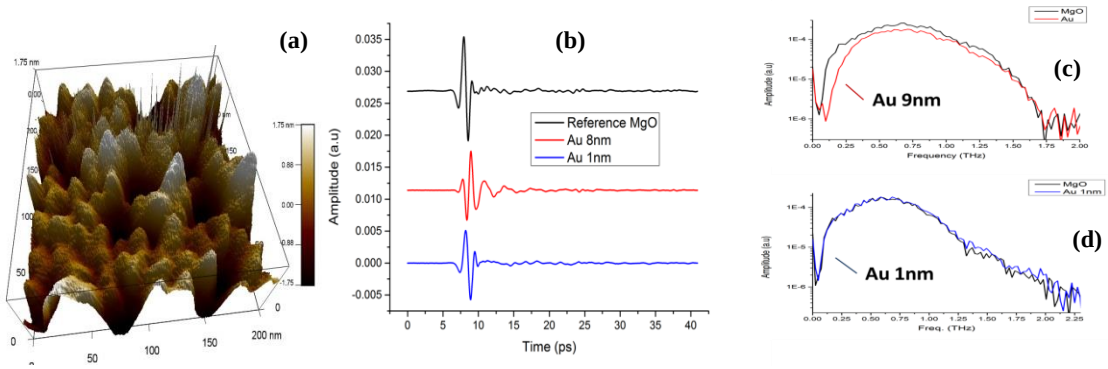

Fig.1: (a) AFM image of 8nm Au on MgO substrate (b) Transverse Electric Time domain pulse of the reference (black), Au thickness 8nm (red) and Au thickness 1nm (blue) (c) Spectrum of the reference (black) and 8nm of Au (red).(d) Spectrum of the reference (black) and 1nm of Au (blue)

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