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※支援課題名（日本語）　：金 2 量体構造のギャップ幅制御
※Program　Title（in English）　：Nanogap control on free-standing gold dimers
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※概要（Summary）：
Metallic dimers are objects that were extensively studied in the last two decades because of their capacity to strongly enhance the EM field thanks to a plasmonic coupling effect. However, optical properties of close contact dimers with only few nanometers gap are still not perfectly understood, as the gap size is technically difficult to control with such resolution. In this work, we propose a new technique that allows adjusting the gap size of free-standing Au dimers with an sub-nanometer resolution. In order to achieve this, a silicon membrane is used as substrate. A glass tip coupled to a nanopositionning system (Attocube) is used to apply a localized pressure on the membrane and thus to induce a controlled stretching of that latter. As a consequence, the distance between all structures supported by the membrane is increased. This results in a slight gap size increase in the case of the dimer.

※実験（Experimental）：
Free-standing Au dimers are fabricated on etched silicon membranes. First, a Cr layer is sputtered over the substrate to act as a mirror and remove all optical contributions from interferences in the Si membranes. As a spacer between the substrates and the dimers, a polyimide layer is coated over the Cr layer. Next, lithography on a coated electrosensitive resist is performed using a high-resolution electron beam writer. After resist development, the dimers are made by depositing a 40 nm thick Au film and by standard lift-off process. Finally, the polyimide is etched by O_2 plasma resulting in a regular array of isolated free-standing nanogap Au dimers (Fig. 1(a)).

The optical properties of single dimers are achieved using a homemade microspectroscopy setup. The light scattered by the structures is collected using a darkfield illumination system. A pinhole is put after the objective to spatially select the light coming from an individual dimer and next sent to a polychromator with a N_2 cooled CCD detector.

※結果と考察（Results and Discussion）：
The scattering spectra of single dimers were acquired for different tip positions, in the vertical axis (Fig. 1(b)). This study especially focused on a light polarization along the main dimer axis, where the plasmonic coupling and so the gap sensitivity is expected to be strong. A clear regular blueshift of the plasmonic resonance was observed for increasing values of the gap size (Fig. 1(c)). As the relation between membrane stretching and gap size modification involve many non-quantifiable contributions, the real gap width was evaluated by comparison of the experimental observations with FDTD simulations. These results showed that atomic scale resolution of the gap control can be achieved with this pushing tip technique.

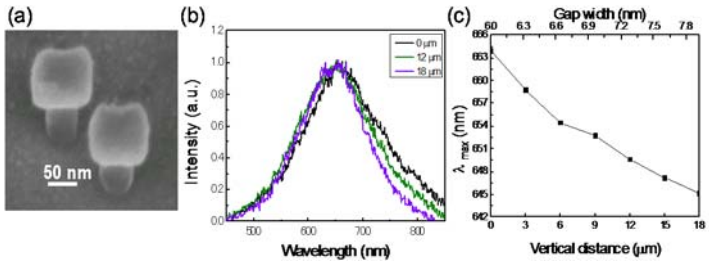

Fig. 1 (a) SEM micrograph of a fabricated free-standing Au dimer. (b). Scattering spectra of a single dimer for different positions of the pushing tip. (c). Experimental observation of the plasmonic resonance blueshift when the gap size is increased.

※その他・特記事項（Others）：
Clearer spectrum shift from a single gold nanoblocks pair will be measured and we will analyze the spectral properties of dimer blocks with a gap distance around 1~3 nm.

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