Title
Using Surface Plasmon Band Gap for robust, on-field, biological and chemical detection

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Using Surface Plasmon Band Gap for robust, on-field, biological and chemical sensing*

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*Patent pending

**Introduction:** Surface Plasmon Band Gap Sensing

**Motivation**

- Sensor Networks need to use miniature-sized sensors for realistic large-scale deployment.
- Surface Plasmon (SP) based sensors can detect a wide range of molecules with slight variations, making them attractive for a versatile sensor network.
  - Within CENS, nitrate and algae detection are two examples of applications of SP sensing under development.
- We invented a new sensor, the Surface Plasmon Band Gap Sensor (SPBG) that can be miniaturizable and detect a wide range of molecules.

**Principle**

- Surface plasmons (SP) are electromagnetic waves propagating on the surface of a metallic interface.
- Their wavelength is strongly dependent on molecular bindings on the surface.
- We showed that it is possible to use nanostructures to measure SP wavelengths using the plasmonic band gap phenomenon: when molecular binding occurs, the propagation of surface plasmon through the nanostructures is forbidden. Therefore, our sensor measures the propagation of SP as a proxy for molecular concentration.

**Problem Description:** Period tuning for band gap observation

- The Surface Plasmon Band Gap is the band of energy for which the propagation of surface plasmon through periodic structures is blocked. This happens when the period of the structures is half the surface plasmon wavelength. Therefore, in order to observe surface plasmon band gaps at a given energy, it is necessary to fabricate structures with precisely the right period. However, at a given frequency, the surface plasmon wavelength is strongly dependent on the surface roughness, which is difficult to control: it is difficult to predict ab initio the desired structure period.
- To overcome this problem, we developed a technology based on nano-stamping that enables us to fabricate sub-micrometer periodic structures with arbitrary period quickly and inexpensively. We are now able to screen quickly different values of the structure period in order to place the system in a surface plasmon band gap situation.

**Proposed Solution:** Period control during high aspect ratio nanostamping

**Nanostamping**

- Nanostamping is a soft lithography technique that can fabricate sub-micrometer structures in a fast and inexpensive way.
- In this technique, an elastomer stamp is covered with an ink. The stamp is then pressed on the substrate. Once the stamp is removed, the ink forms submicrometer structures.
- In our implementation of the technology, the ink was n-propyltrimethoxysilane, PTMS, an alkoxysilane. Alkoxysilanes are commonly used to form Self Assembly Monolayers (SAM) for coating applications.
- In our case, by choosing a short radical chain (propyl), PTMS molecules can condensate between each other to form a tridimensional polymer network, which is much thicker than a SAM. Therefore, we obtain exceptionally high features for a nanostamping process.
- We obtained feature heights of 60 nm for 277 nm gratings, and 150 nm for 1200 nm gratings. Our numerical simulations show that this is enough to create a substantial band gap. As a comparison SAM based nanostamping usually yields to 1 or 2 nm feature height.

**Stretching mechanism**

- In order to easily scan grating periods, the stamp was mounted on a stretching apparatus. The positions of the first order diffracted beams were used to measure in real time the stamp period. Therefore, we were able to control the period of the final grating with a precision of only a few nanometers.

**Cross-section of a non-stretched grating (Top) and a stretched grating (bottom) obtained from a 3600g/mm grating.**

**Atomic Force Microscope Image of the final grating**