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ESRF	**Experiment title:** X-ray probe of surface plasmons generated by multiple surface gratings of azopolymers	**Experiment number**: SI-1498
Beamline: ID 10B	**Date of experiment**: from: 05.05.07 to: 08.05.07	**Date of report**: 21. 08. 07
Shifts: 12	Local contact(s)**:** Federico ZONTONE	*Received at ESRF:*

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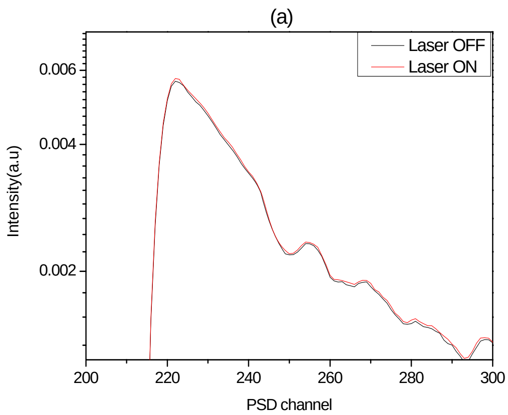
Report: A surface plasmon is the collective excitation of electrons at the interface between a conductor and an insulator. It represents an electromagnetic surface wave which has maximum intensity in the surface and exponentially decreasing fields' perpendicular to it [1,2]. The origin of non radiative nature of surface plasmon is that the interaction between light and surface plasmon can not simultaneously satisfy energy and momentum conservation. This restriction can be circumvented by using grating coupling (that is corrugated surface) so as to increase the effective wave vector and hence the momentum. The important property of surface plasmon is their coupling with photons via corrugated surface. With the excitation of surface plasmon with light, a strong enhancement of the electromagnetic field in the surface (resonance amplification) is combined, which can be rather strong. This field enhancement has found many applications: Enhanced photo effect, non linear effects as the production of second harmonic generation SHG in the strong field, surface enhanced Raman scattering, amplification of waves scattered by Rayleigh wave, surface plasmon resonant technology and many photonic applications which makes the study of surface plasmon more important.

The experiment is performed at ID 10B beamline at ESRF, Grenoble. The ID10B beam line offers high resolution scattering instrumentation for vertical and horizontal scattering geometry and an energy tune ability from 8keV < E < 13keV. The distance between the sample and detector was 67cm. The detector used is a PSD which offers a resolution upto 0.025nm. Prior to the experiment two grating of periodicity $\mathbf{D_1}$=501nm and $\mathbf{D_2}$=770nm are written on an azobenzene polymer film using interference pattern of two coherent beams. The gratings height (**a**) is about 20-25nm. After writing the gratings are covered by a thin layer of gold (50nm) using sputtering technique.
The wavelength of the incident light and the angle at which the incident light couples into surface plasmon is selected from the momentum relation

$$\mathbf{K}_{sp} = \mathbf{K}_{light} \sin\theta \pm \mathbf{K}_{grating.}$$

For the above two gratings light will couple into counter-propagating surface plasmons at the appropriate wavelength and angle of incidence. This results in a surface plasmon standing wave, this in turn results in a periodic surface charge distribution at the interface. In the present experiment, a monochromatic **'p'** polarised light of wavelength λ=633nm is incident on a sample at an angle of around 12.5° with the normal. The surface charge distribution resulting from the coupling of light that generates a surface plasmon standing wave is probed using X-ray beam of dimension of 50x500 µm. The scattering of the x-rays from the periodic surface charge variation should result in an enhancement of the x-ray Bragg peaks scattered from a periodic structure. This effect should be observable by difference in the intensity of the two spectrums, one with the incident light 'on' and other with the incident light 'off '. Figure (1a) shows a scan when the sample is aligned in such a way that x-ray beam is parallel to the grating (ω=0). The scan is then performed without switching the laser light on (black curve) and with the same angular settings switching the laser light on (red curve). The difference in the intensities of the two curves shown in Fig.(1b) is not significant even after integration of several difference spectra



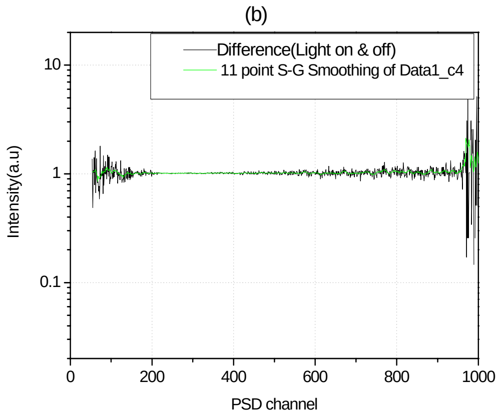
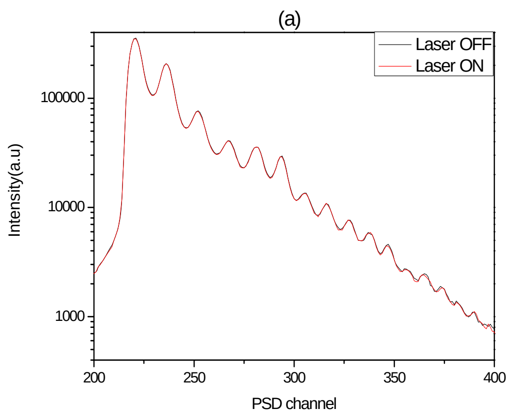


Figure 1 (a) Coupling of light into surface plasmon

Figure 1(b): Difference in the intensities

When the sample is rotated through certain degrees (ω=12°), one can see several grating Bragg peaks (Fig.2a). Here, it is expected that the intensity or position of one or more peaks would change when the surface plasmon standing wave is generated. Unfortunately again the difference spectrum integrated over several runs does not show a significant effect.



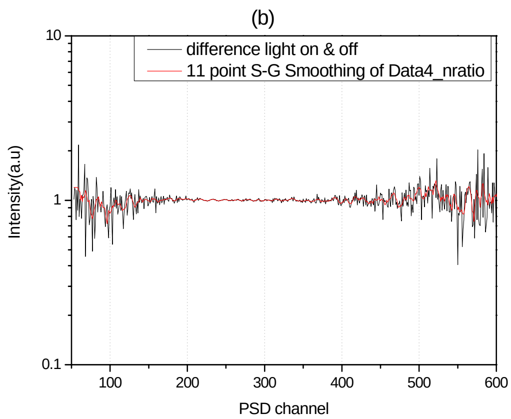


Figure 2 (a) Coupling of light into surface plasmon

Figure 2(b): Difference in the intensities

The small effect observed can be attributed to the relatively low number of electrons excited into surface plasmon mode by the optical setup used. This is mainly due to the fact that the intensity of optical light which has been coupled into the sample was too low to result in a significant charge density change. The plasmon resonance is very sharp in angle. Unfortunately the angular divergence of the optical laser used was much larger as the width of the plasmon resonance. Therefore only a small fraction of the light could be coupled into the plasmon mode. For a next experiment we have to prepare an optical collimation setup in addition to using a higher intensity laser. Furthermore, the plasmon excitation has to be realized over the whole surface area illuminated by the x-ray beam.

References

[1] P. Rochon, and L. Levesque, Optics Express 14, (2006) 13050.
[2] H. Raether, Surface Plasmons, Springler- Verlag, Berlin, 1998.