# Phase gratings for plasmon focusing

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**Abstract**: We report gratings structures realized for the creation of focused plasmons through noncollinear phasematching. The gratings are created on gold by focused ion beam milling and the plasmons were measured using phase sensitive PSTM.
**Keywords:** Surface plasmons; Fourier optics; Scanning microscopy

Surface plasmons can be exited resonantly by incident light when the plasmon k-vector matches the light k-vector projected onto the surface [1]. A grating vector on the surface can shift the latter in an engineered continuous way. An appropriately crafted grating can ensure the creation of plasmons in a predefined direction, e.g. towards a common center [2]. For perpendicular illumination the required grating profile for converging plasmon creation is a saw toothed bulls-eye phase pattern, where the grating periodicity matches the plasmon resonance at the illumination wavelength. This saw-tooth is the result of the $2\pi$ periodic projection of a cone shape. The optical element equivalent of this pattern is the axicon or conical lens that deflects light like a prism rather than focusing it, creating a circular symmetric tilt to the angle of incidence towards the center so that plasmons can be created at the resonant plasmon angle in a circular symmetric pattern. To achieve focusing of plasmons for *angled* incident illumination the grating has to add less k-vector before the focal point and more behind the focal point so that the grating pattern resembles cuts through an angled cone, yielding shifted circles; corresponding to the Fourier transform of a circle in k-space that has radius corresponding to the plasmon resonant k-vector and is shifted from the center by an amount corresponding to the projected light vector of the angles illumination.

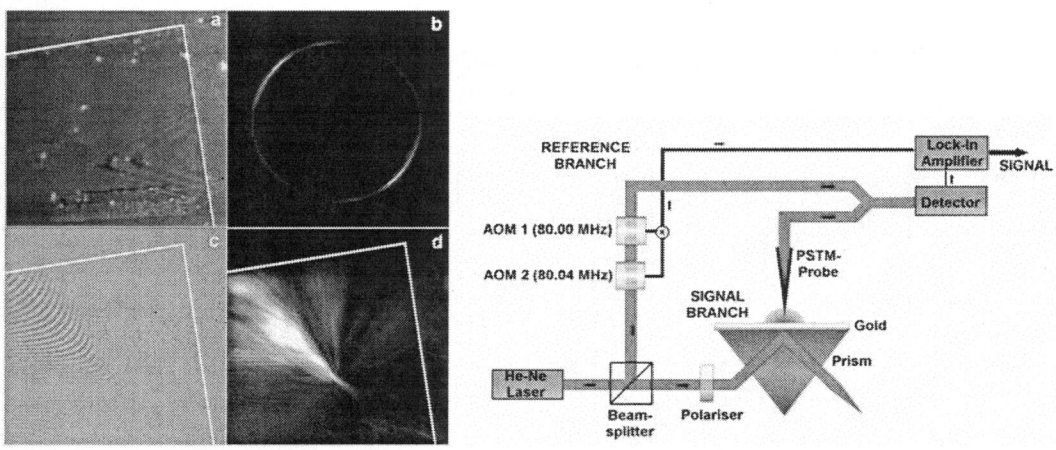


Figure 1, Focusing grating, angled illumination, polarization tilted at 30 degrees. Topography (a), measured field (c), Fourier transform (b), amplitude only (d). The white line indicates the border of the grating. Figure 2 Phase sensitive Photon Scanning Tunneling Microcoscope (PSTM) setup. The grating profile is on the top side of the gold layer.

We present local probing of the plasmon propagation by phase sensitive PSTM (fig 2) of the field distribution on two-level bullseye gratings and angled cone-gratings (fig 1), showing the focusing and directing of beams of plasmons. The gratings are created in a thin (50nm) gold layer by Focused Ion Beam (FIB) milling.

Plasmons created on shaped gratings like these hold promises for the creation of efficient and highly confined excitation sources at optical frequencies. The optimal shape of the gratings for focusing beyond the diffraction limit will be the subject of future research.

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[2] H.J. Lezec, A. Degiron, E. Devaux, R.A. Linke, L. Martin-Moreno, F.J. Garcia-Vidal, T.W. Ebbesen, "Beaming light from a subwavelength aperture", Science **297**(5582), pp. 820-822 (2002)

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