Surface Electromagnetic Wave Assisted Photoelectron Source for Multi-electron Beam Applications

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Distributed axis multiple e-beam systems have been proposed as an effective means of overcoming the two factors which have historically limited throughput for e-beam inspection and lithography[1,2]. These are the serial nature of the scanning process, and Coulomb scattering within the beam path. This latter limits the useful beam current for a given resolution. Realization of such a distributed multibeam system hinges on the availability of a massively parallel multi-beam electron source.

As a practical solution, we propose a novel photoelectron source, driven by surface electromagnetic (EM) waves, placed in an array and individually controlled in parallel (Fig. 1). Each source can be driven in principle by light transmitted through an optical fiber. Surface EM modes are excited when a photon is scattered from a subwavelength groove or slit on a metal/dielectric surface. These surface modes, called *compound diffracted evanescent waves* (CDEW), carry away some of the incident photon energy along the surface as an evanescent EM wave[3,4]. By using periodic concentric rings of grooves on a thin metal film, photon energy incident on a large area can be captured, and guided to a sub-wavelength aperture at the center of the rings that transmit the energy to the opposite side of the film. This allows the enhancement of the transmitted photon energy, focused to a subwavelength spot, which can be used to excite a photoelectron-emitting nanoparticle placed at the center of the structure. An array of such electron sources could be used in multi-beam applications.

Using 2D computer simulations, an array of grooves surrounding a slit has been investigated and the geometrical parameters of the structure have been optimized for use at incident wavelength of 525nm (Fig. 2). The resulting structure exhibited an enhancement of 16x compared to that of a slit with no grooves, and a 3x enhancement of the power density incident on the structure (Fig. 3). One might also expect further localized enhancement of the evanescent waves by interaction with the nanoparticle. The inherent gain in such a system has the potential for a very bright photoelectron source a few nanometers in size, which can be integrated into a massively parallel array.

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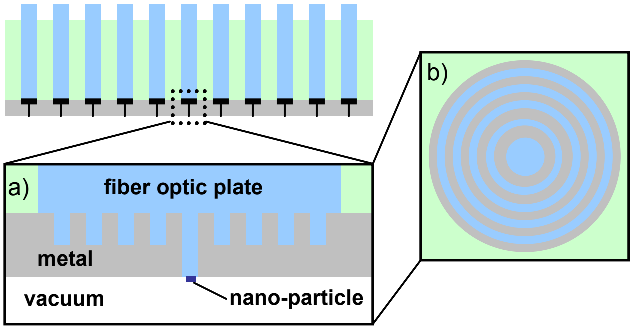

Fig. 1: Proposed array of *Surface Electromagnetic Wave Assisted Photoelectron Source*. Surface structures are printed on a fiber optic plate that focuses the light and directs it through an aperture to a photo-electron emitting nano-particle. **a)** side view of the plate/metal/vacuum layers. **b)** top view of the surface structure.

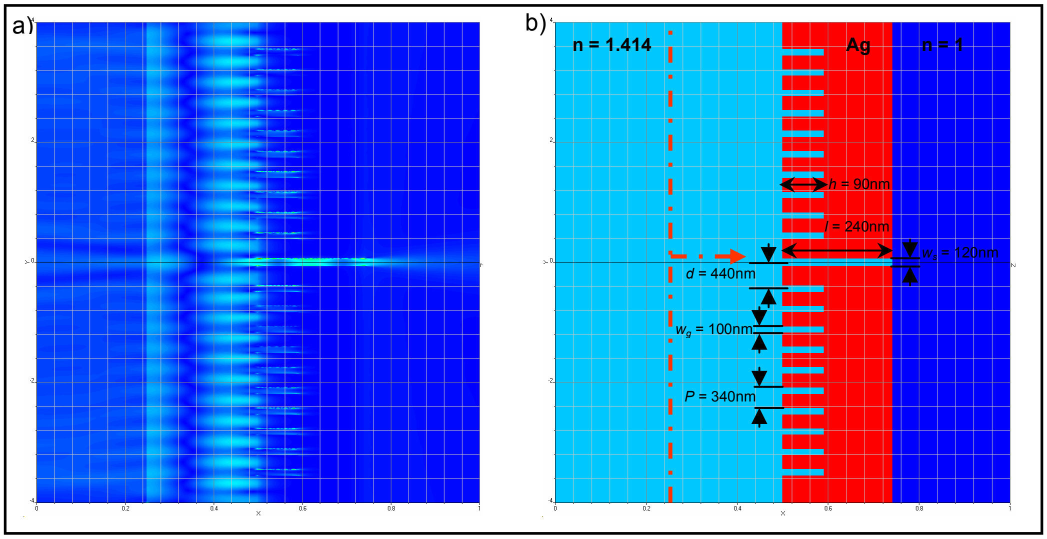

Fig. 2: 2D simulation result **a)** of the optimized test structure **b)** consisting of a glass (n=1.414)/Ag/vacuum layer, with grooves surrounding a sub-wavelength slit. The photon energy is collected by the grooves as surface waves, and is focused through the slit.

Fig. 3: Transmission enhancement spectrum of the optimized structure. Red line: enhancement compared to single slit with no grooves. Blue line: enhancement of power flux compared to the input wave