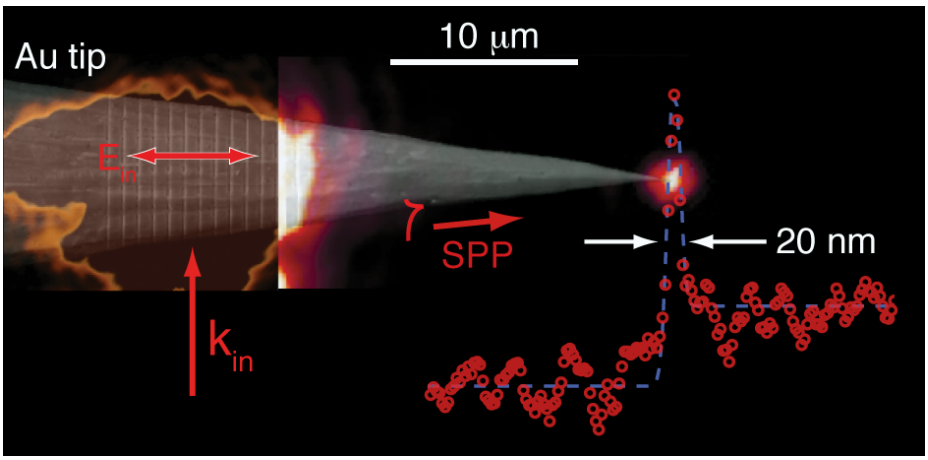
The World's Smallest Flashlight?

Scientists focus light beyond the diffraction limit, creating nanometer-sized light source

Researchers from the University of Washington and University of Gottingen, Germany, in collaboration with the U.S. Department of Energy's EMSL created a true nanometer-sized light source, surpassing the diffraction limit. Under normal optical excitation, the diffraction limit prevents the focusing of light into regions smaller than several hundred nanometers in diameter. This new light source, with both high brilliance and contrast, provides focused light more than one order of magnitude below the diffraction limit.



A grating, written on a gold cone using a focused ion beam, leads to surface plasmon coupling of incident laser light with near-infrared wavelength. The surface plasmon polaritons effectively help focus the light which when remitted from the gold nano-tip has a radius less than or equal to 15 nm. The graph indicates the lateral optical scan used to measure spatial field confinement and size of the emitter at the apex. In this case, the width of 20 nm demonstrates the highly confined light source.

Led by Professor Raschke at the University of Washington, the scientific team converted light energy into propagating surface waves or surface plasmon polaritons on a conical tip using a special nano-fabricated grating. This grating structure was created using the focused ion beam at EMSL. As these waves propagate towards the tip, their field energy converges into the apex of the tip, creating a spatially confined intense light source. These nanometer-sized tips act as optical antennas capturing light from conventional sources and confining it to the nanoscale.

Scientific impact: This research used fundamental knowledge to design and construct a structure that enabled a significant breakthrough using surface plasmon polaritons to create an intense and highly focused light source useful for scientific studies which will have a range of technological applications. This is part of EMSL's efforts in designing and controlling material synthesis and has applications to EMSL's objective of materials characterization with unprecedented resolution.

Societal impact: This research presents a novel light source with applications ranging from solar cells to medical imaging. For example, this light source could improve field-enhanced microscopy, antenna-based sensing, non-linear frequency mixing for higher harmonics generation, and photoelectron microscopy. In addition, it could open new ways of harvesting light for photovoltaic applications. Also, it could help "see" biomarkers or diseased cells in situ.

For more information, contact EMSL Communications Manager Mary Ann Showalter (509-371-6017).

Reference: Neacsu, CC, S Berweger, RL Olmon, LV Saraf, C Ropers and MB Raschke. 2010. "Near-Field Localization in Plasmonic Superfocusing: A Nanoemitter on a Tip." *Nano Letters*. DOI: 10.1021/nl903574a

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