Towards complete control of light at the nm scale

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In this work we present the successful fabrication of a well-defined functional plasmonic antenna on a SPM tip with a novel nanofabrication method, showing a Raman enhancement factor on the order of $5*10^5$. Research and Development of plasmonic/optical antennae is a topic of high interest since these antennae allow manipulating light in the visible regime on the nm scale. Much work has been published on the basic characterization of metal nano particles as optical antennae. Presently much effort is invested into the next R&D phase, that is the implementation of well-defined optical antennae into actual devices to employ properties such as optical near fields localized on the order of 10 nm and 3 orders of magnitude near field enhancements. A significant application for localized optical Near Fields is Tip Enhanced Raman Spectroscopy (TERS), which enables the imaging of single proteins and can potentially be used for chemical mapping with a resolution down to individual molecules. With our novel nanofabrication method Induced Deposition Mask Lithography (IDML) we were able to address the lack of a nano fabrication method for the reproducible, well-defined fabrication and flexible placement of optical antennae, which is a key problem for the implementation of optical antennae into devices. Here we present IDML by fabricating bowtie optical antennae and the instrumentation used. The functionality of the optical antenna is demonstrated, which we characterized via dark field spectroscopy and showed for the first time a well-defined functional dipolar optical antenna placed on a SPM tip getting large enhancements from CNTs. Furthermore we showed how symmetry effects as well as aspect ratio variations allow the specific design and engineering of optical antennae for particular systems.