Chirality in Low-cost Plasmonics: asymmetric nanohole arrays

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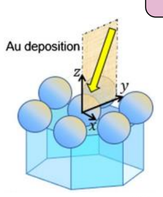
Abstract **Plasmonic nanohole arrays offer applications spanning from biosensing to communications. Here we show yet another possibility enabled by low-cost fabrication and symmetry breaking: chiral effects. When the nanoholes are elliptical and tilted away from the lattice symmetry lines, they differently interact with circular polarizations of opposite handedness, i.e. they exhibit circular dichroism (CD). We apply a low-cost, simple nanosphere lithography combined with tilted silver or gold evaporation. We experimentally and numerically investigate intrinsic and extrinsic chirality and CD in various samples in the near-infrared range.**

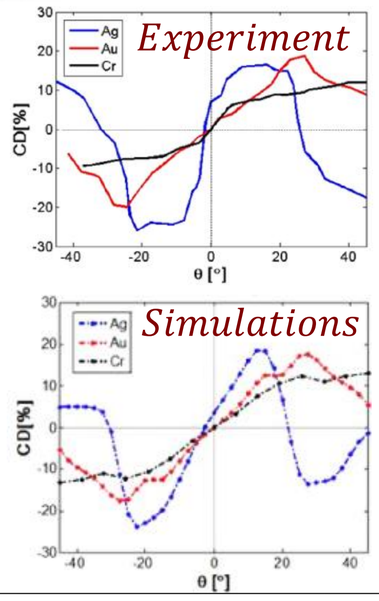
Design and Experiments @SBAI

- Chiral nanostructures exhibit CD = different absorption (extinction) for left and right circular polarization (LCP,RCP)
- Low-cost nanosphere lithography [1] combined with tilted deposition of plasmonic layers provides chiral samples
- Instrinsic chirality = sample is chiral itself [2]
- Extrinsic chirality = nonplanar triad of vectors $\vec{k}$, $\vec{s}$, and $\vec{n}$ [3]
- FDTD calculations in Lumerical for CD optimization in desired wavelength range
- Optical and photothermal techniques for CD characterization [4-6]
- Synthetization of new chiral substances and their deposition on the substrates for novel CD measurements

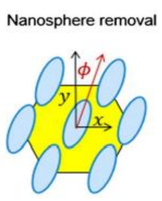
Previous results [5]



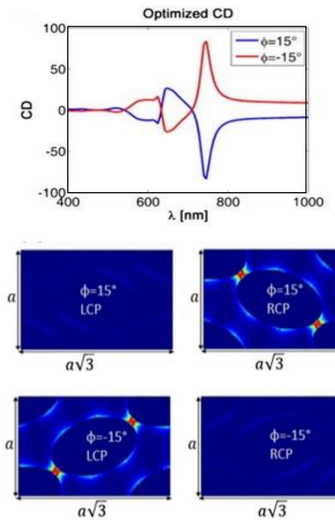
$$CD = \frac{A_{LCP} - A_{RCP}}{A_{LCP} + A_{RCP}} \cdot 200$$



Novel design



$$CD = \frac{A_{LCP} - A_{RCP}}{A_{LCP} + A_{RCP}} \cdot 100$$

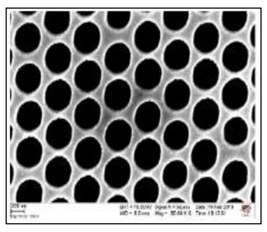


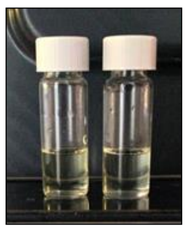
Current work

1) CD characterization of newly fabricated chiral nanohole arrays

2) Deposition of chiral substances with different enantiomer concentrations

3) CD characterization of the system: nanohole array + chiral layer





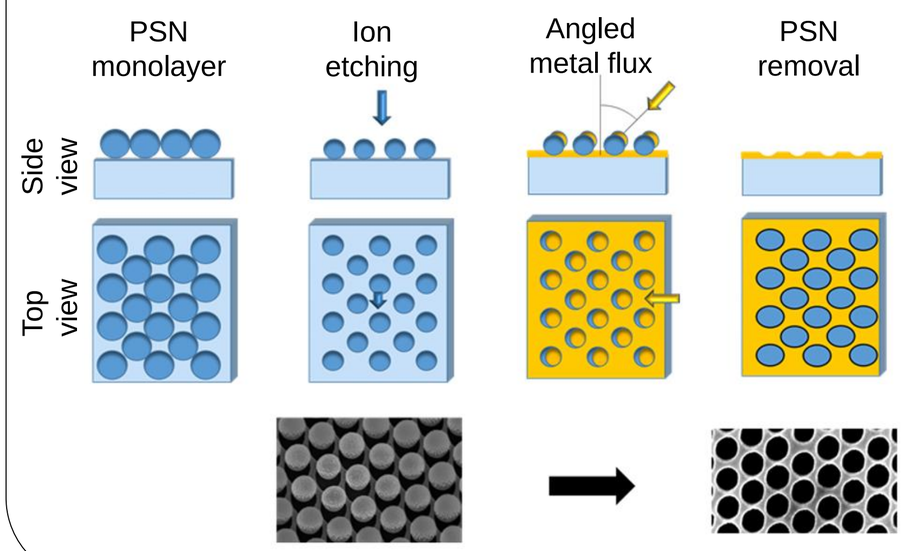
Fabrication @NSG

- Nanosphere lithography = low-cost , simple technique enabling fabrication of various plasmonic nanostructures with hexagonal unit cell
- Commercial polystyrene nanospheres (PSN) self-assemble to a close-packed monolayer on the soda-lime glass substrates
- PSN diameter is then reduced
- A thin layer of plasmonic material is deposited under some oblique angle
- An additional in-plane angle of evaporation is introduced for intrinsically chiral samples

→ samples are uniform 2D arrays of plasmonic semishells with plasmonic grid on the substrate

- Final step: PSN are mechanically removed

→ plasmonic grid on the substrate forms chiral nanohole arrays

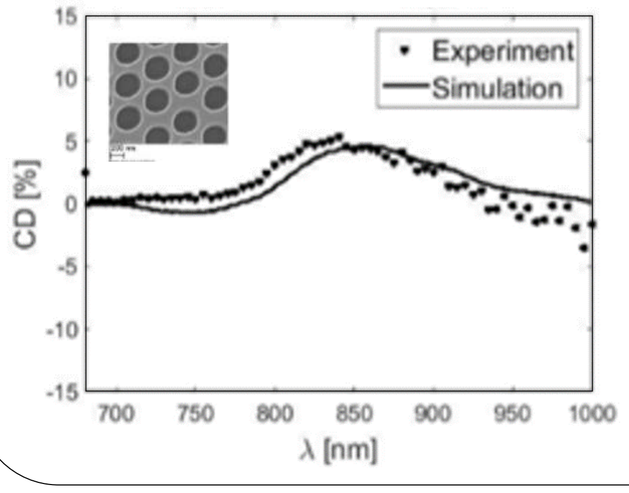


CD characterization of newly fabricated nanohole arrays

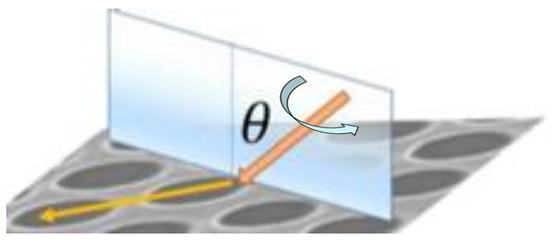
- Widely tunable near-IR laser Chameleon Ultra II
- Spectral range: 680-1080nm
- CD is extracted from extinction measurements

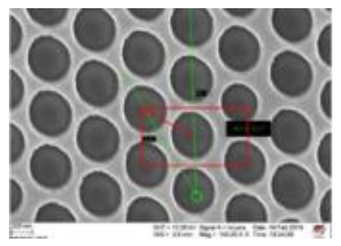
$$CD[\%] = \frac{Ext_{LCP} - Ext_{RCP}}{Ext_{LCP} + Ext_{RCP}} \cdot 100$$

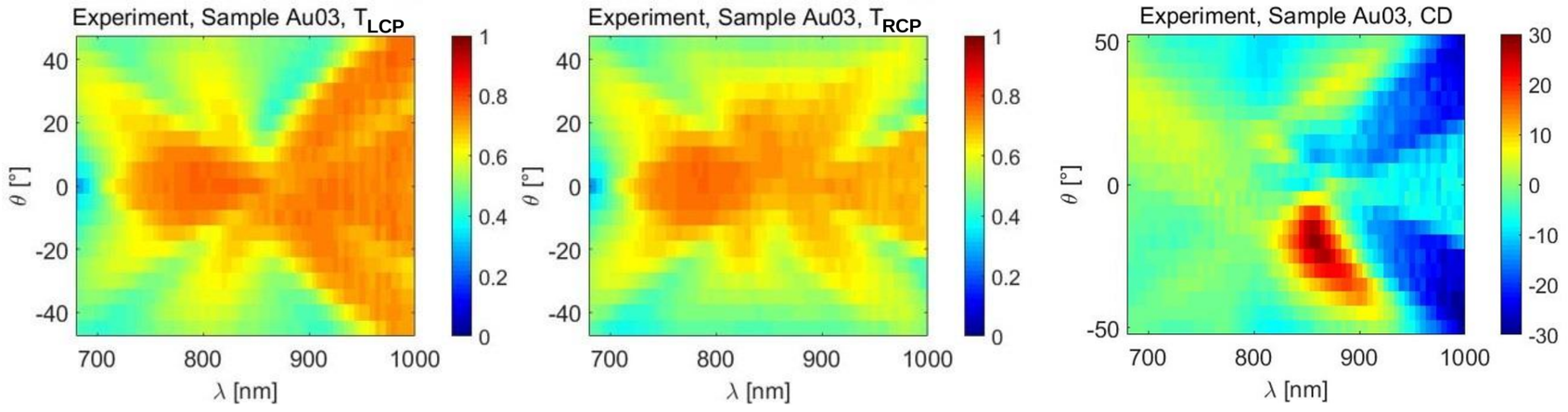
- E.g. sample AuD2: Ag/Au 9+43nm, angled flux at 45”, in-plane tilt 28”
- Good agreement with simulations



- CD extinction set-up is adapted for oblique incidence: extrinsic chirality
- E.g. sample Au03: Au 50nm, angled flux at 45”, in-plane tilt 28”
- Plan is to confirm these measurements with photo-acoustic technique and then with chiral molecules







Conclusion **We have demonstrated chiral behavior of asymmetric nanohole arrays in metal. The samples were fabricated by means of low-cost nanosphere lithography. CD in extinction was measured for intrinsic and extrinsic configuration in various samples. The chiral properties were further investigated numerically. We strongly believe that this approach can lead to lower-cost applications in chiral sensing and chiral light manipulation at the nanoscale.**

References

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