Supporting Information

An orbital angular momentum-controlled hybrid nanowire circuit

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This Supporting Information file includes additional details about device simulation (Figs. S1, S2, S4, S7), experimental performance (Fig. S6 and Table S1), and schematics of the device (Fig. S3) and optical setups (Figs. S5 and S8).

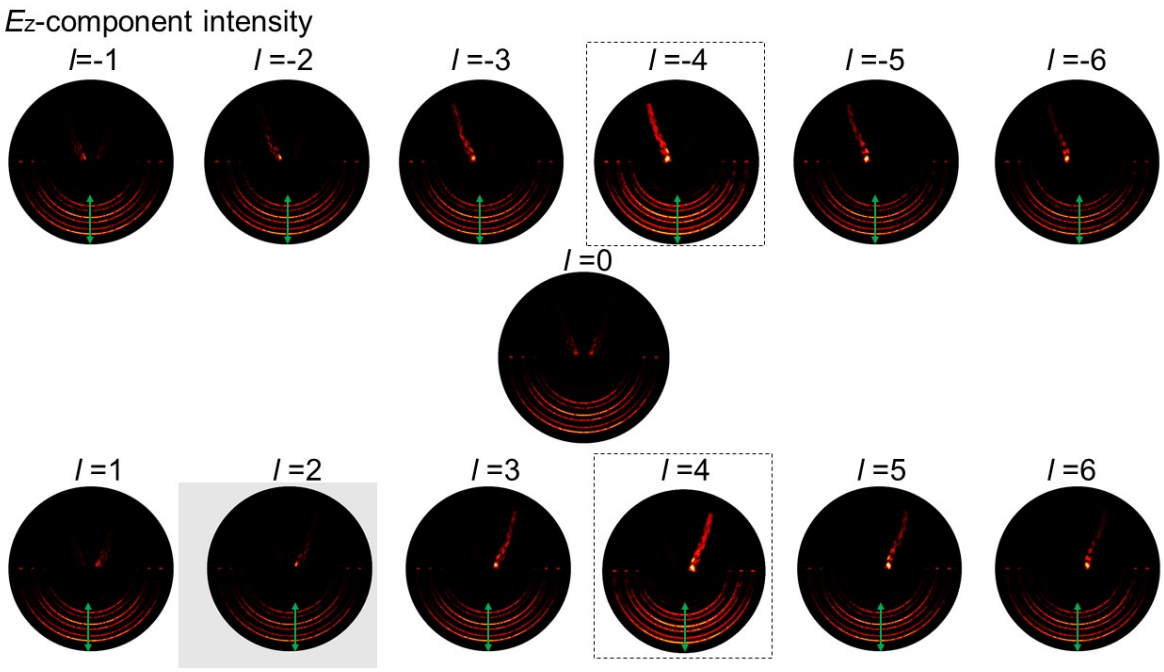


Figure S1. Numerical simulation of the coupling of OAM-distinct plasmonic fields into CdS nanowires, under the illumination of different OAM modes ranging from *l*=-6 to *l*=+6. The dashed rectangle labels the selected OAM modes for our proof-of-concept experiment. The E_z-component of the plasmonic field was shown. The excitation wavelength is 490 nm.

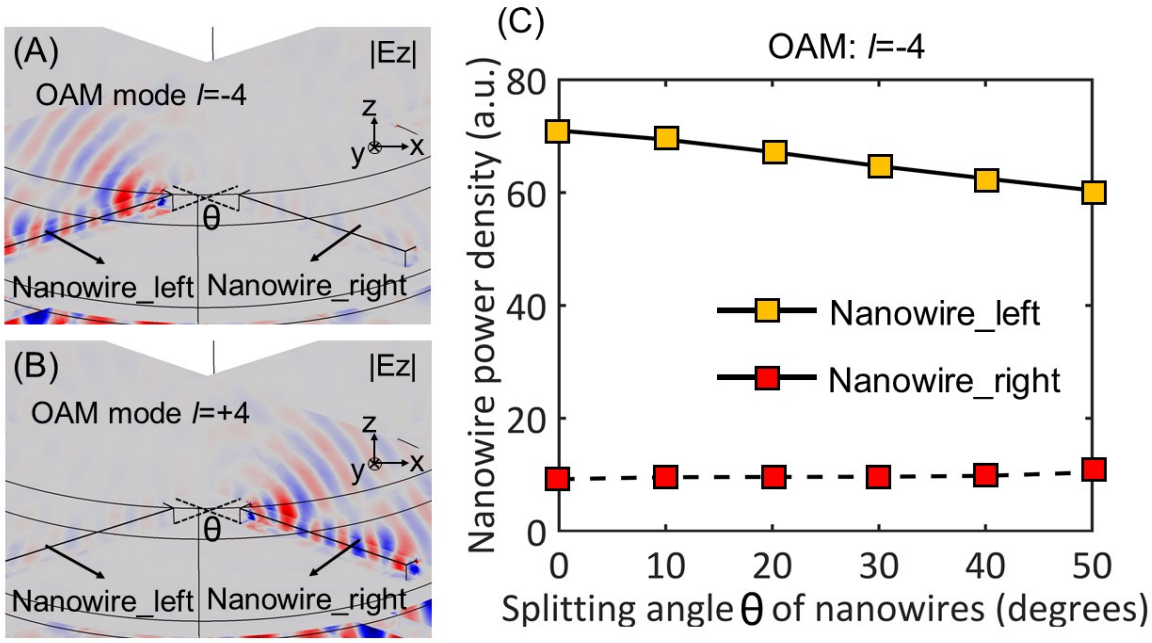


Figure S2. Simulation results of splitting angle-dependent nanowire coupling. (**A-B**) Simulated E_z-component of plasmonic fields coupled to the CdS nanowires on the left and right, under the OAM incidence of l=-4 (A) and l=+4 (B), respectively. (**C**) Splitting angle-dependent nanowire coupling power density (E_z electric field component) in the CdS nanowires on the left (solid line and yellow boxes) and right (dashed line and red boxes), respectively. The OAM incidence is l=-4.

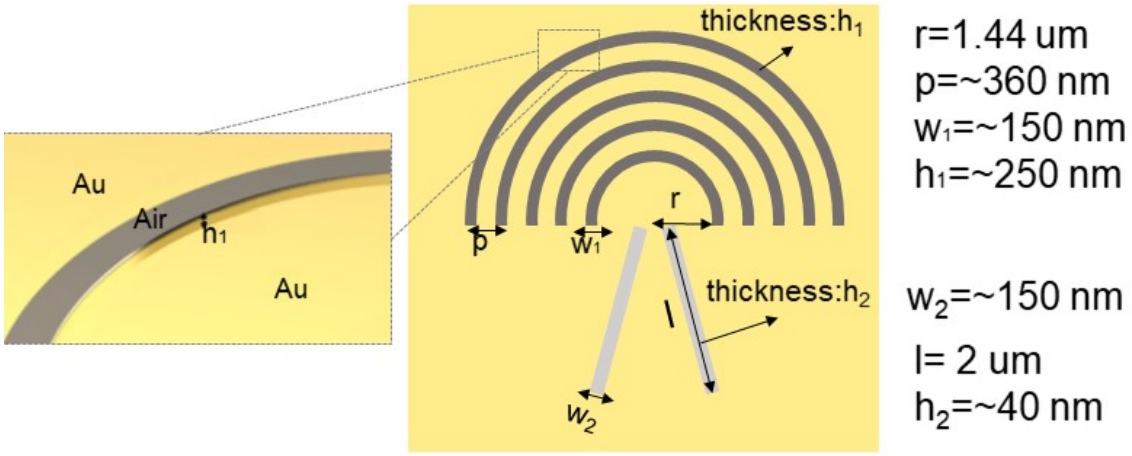


Figure S3. Schematic of an OHNC device (before the nanowire transfer) consisting of a semi-circle-shaped nanogroove grating and two shallow lines to mark the transfer position of nanowires. The geometrical parameters of the nanostructures are labelled in the figure.

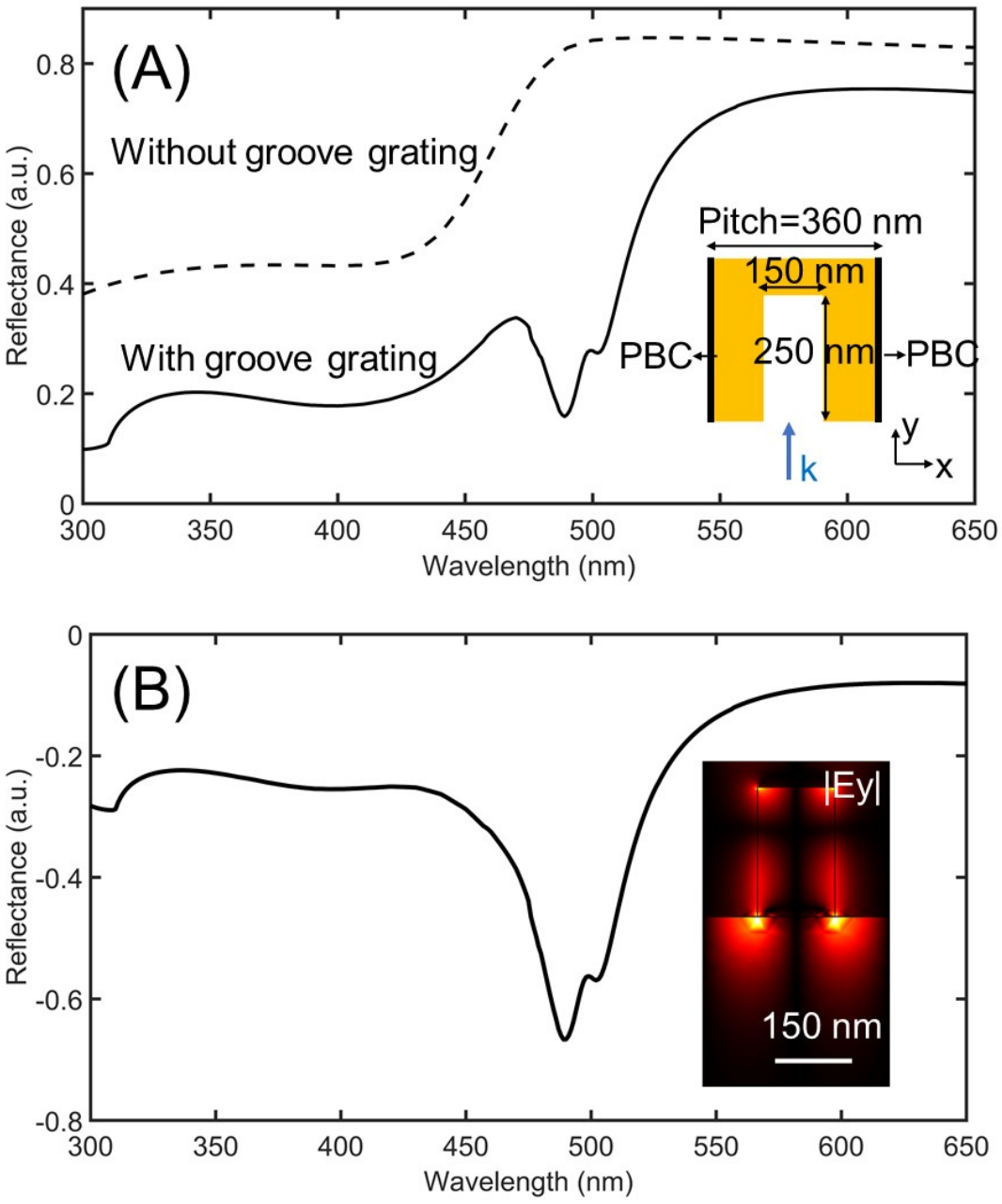


Figure S4. An optimized plasmonic nanogroove grating for an efficient conversion of light into surface plasmon polaritons. (**A**) Reflectance spectra of a gold film with (solid curve) and without (dashed curve) the nanogroove grating structure, of which the dimensions are labelled in the inset. (**B**) Differential reflectance spectrum between the spectral data in (A), exhibiting a strong plasmon resonance at an incident wavelength of 490 nm. The inset shows the excited plasmonic field profile at the resonance. PBC: periodic boundary condition.

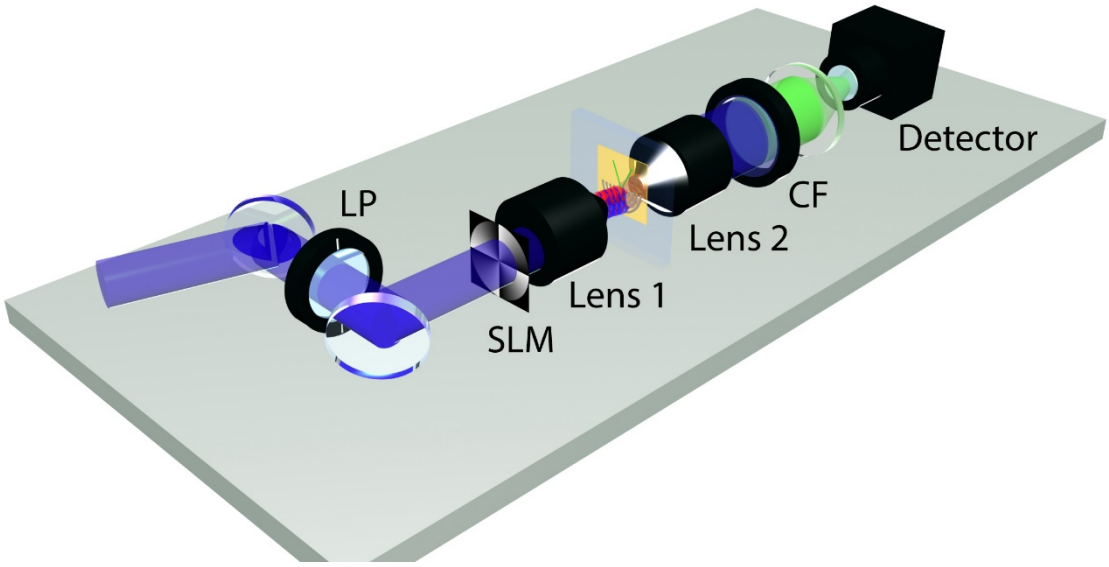


Figure S5. Optical Setup for the experimental characterization of the OHNC device. LP: linear polarizer; SLM: spatial light modulator; Lens 1: an objective lens with the numerical aperture (NA) of 0.8, used for locating the OHNC device and providing the OAM incidence. Lens 2: an objective lens with the NA of 0.3, used for collecting the photoluminescence signals from the OHNC device. CF: colour filter; Detector: a charge coupled device or a spectrometer.

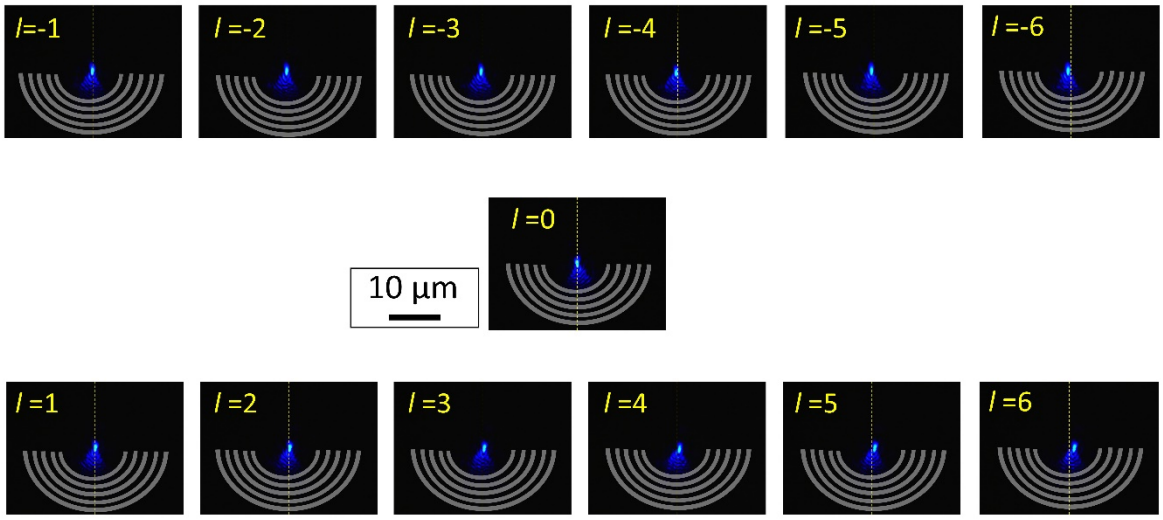


Figure S6. Experimentally obtained plasmonic fields excitation under different OAM incidence ranging from *l*=-6 to *l*=+6. The images were collected from a high-NA microscope system (NA=0.8) with an equivalent magnification rate of 200.

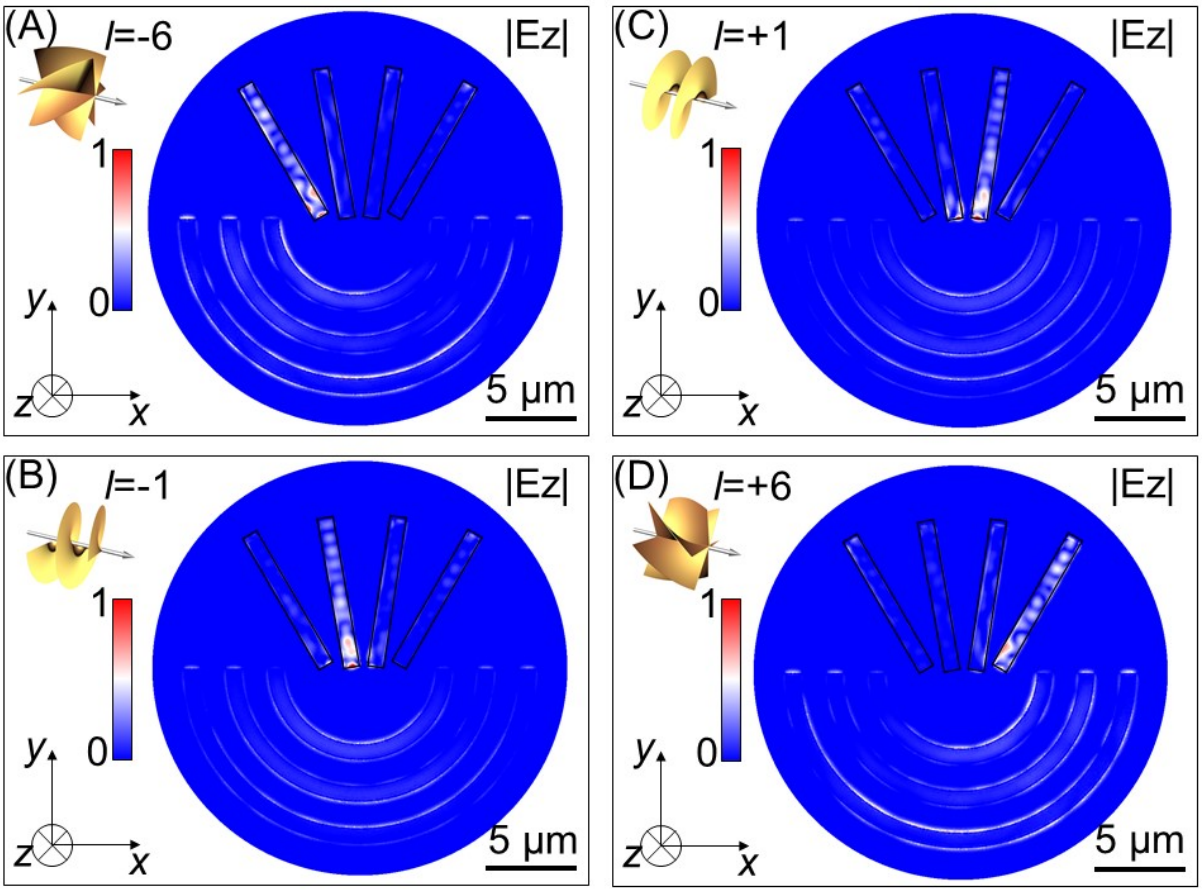


Figure S7. The numerical design of a four-input OAM circuit based on the same semi-circle-shaped nanogroove plasmonic grating presented in Fig. 2.

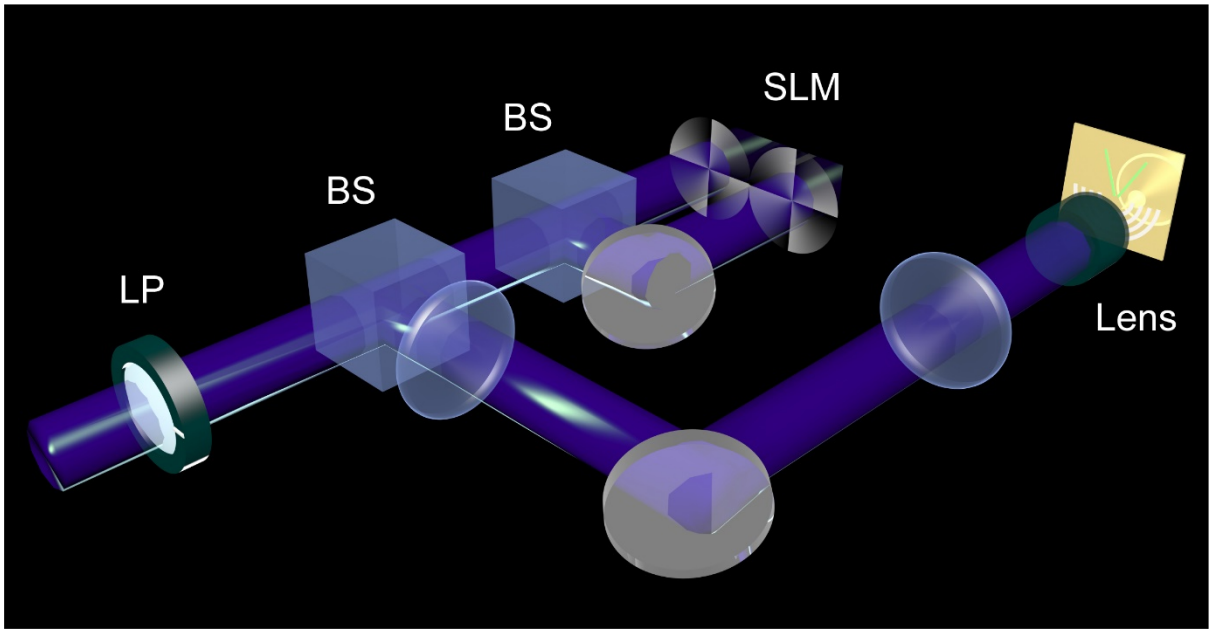


Figure S8. Optical setup for the demonstration of OAM encryption using a SLM and on-chip decryption using an OHNC device. The two OAM key share images (Fig. 5A in the main text) were encoded as temporal signals using a split-screen SLM to display spiral phase holograms with *l*=-4 and *l*=+4. LP: linear polarizer; BS: beam-splitter; SLM: spatial light modulator.

Table S1. A performance comparison of different OAM-based plasmonic devices.

Publications	Number of angular momentum modes	Incoupling structures	Outcoupling structures	Power efficiency
This work	2	Plasmonic grating	Semiconductor nanowires	~10%
Ref. 11	4	Scattering grooves	Subwavelength apertures	~0.01%
Ref. 13	4	Scattering grooves	Subwavelength apertures	~0.01%
Ref. 25	4	Plasmonic grating	Tapered gold tip scatter	Not given
Ref. 26	4	Plasmonic grating	Subwavelength aperture	Not given
Ref. 27	2	Plasmonic grating	Subwavelength apertures	Not given
Ref. 28	2	Plasmonic grating	Subwavelength aperture	Not given
Ref. 29	5	Plasmonic grating	Near-field scanning optical microscope	Not given
Ref. 30	2	Plasmonic grating	Trapped nanoparticle	Not given
Ref. 31	10	Scattering grooves	Near-field scanning optical microscope	Not given
Ref. 52	6	Plasmonic grating	Plasmonic grating	Not given