Supporting Information- Methods and Materials

Preparation of DDT- and TAC-functionalized Co-doped ZnO nanowires

Co-doped ZnO nanowires were prepared by solvothermal reaction. Zinc and cobalt nitrate salts were dissolved in 150 mL of ethanol to 6.67 mM of total metal ion with 10 mol % cobalt. 1.2 g of sodium hydroxide was added, and the solution was stirred vigorously at room temperature in air for 1 hour, or until the NaOH was mostly dissolved and the solution was turbid. The solution was then sonicated for 30 minutes directly after removing from the stir plate using a Branson Sonifier 450 probe sonicator with a power input of 25 W. Finally, 7.5 mL of ethylenediamine (EDA) was added and the solution was quickly transferred to a Teflon liner and sealed in a stainless steel autoclave which was placed in a 130 °C oven for 2 days. After naturally cooling to room temperature, the brightly-colored green-blue reaction products were collected and purified by thorough washing with water and ethanol to increase pH and remove any remaining organic material. After drying overnight in a 65 °C oven, the Co-doped ZnO nanowires were functionalized with either a long-chain alkyl thiol to permit dispersion in organic solvents or with a silane to permit dispersion in aqueous solvents.

In a standard thiol functionalization protocol, 120mg of nanowires were first dispersed in 2 g of chloroform, then mixed with 0.89 g of 1-dodecanethiol (DDT) (Sigma-Aldrich) and left to shake overnight at 1000-1200 rpm on a standard laboratory vortex mixer. The products were collected by centrifugation and rinsed with chloroform several times to remove excess thiol and then dried overnight in a 65 °C oven. The process for silane functionalization is analogous. 100 mg of ZnO nanowires were dispersed in n,n,n-trimethyl-3-(trimethyoxysilyl)propan-1-aminium chloride (TAC) (Sigma-Aldrich) in methanol (6 mL, 0.001M,) and were washed thoroughly in methanol before drying.

Preparation of CoZnO-P3HT:PCBM composite dispersions

Donor-acceptor dispersions of Co-doped ZnO nanowires in conjugated polythiophene for alignment *via* rotational annealing in solution were prepared by dispersing nanowires to 3 wt. % of a 3 wt. % poly([2-(3-thienyl)-ethyloxy-4-butylsulfonate)] (PTEBS) (American Dye Source, Inc.) The dispersion was left to shake for 1 day at 1000-1200 rpm on a standard laboratory vortex mixer.

Donor-acceptor dispersions of Co-doped ZnO nanowires in a poly(3-hexylthiophene-2,5-diyl) (P3HT) (regioregular, electronic grade, Rieke Metals) and phenyl-C_{61}-butyric acid methyl ester (PCBM) (Nano-C) solution were prepared by dissolving P3HT:PCBM in a 1:1 ratio to 25mg/mL in *o*-dichlorobenzene (DCB) (Sigma-Aldrich) and leaving to shake at 1000-1200 rpm for 1 day on a standard laboratory vortex mixer. Co-doped ZnO was added (dispersed in 50μL chloroform per 5mg of nanowires to aid in blending) until it represented 20 wt% of the polymeric solids mass. The dispersions were mixed overnight to form homogenous nanowire-polymer blends. After mixing, the nanowires remained stable in the organic solution against sedimentation for several hours due to compatibilization with the alkyl thiol.

Magnetic alignment

Magnetic alignment experiments were performed with a superconducting electromagnet designed by American Magnetics Inc. capable of producing a 6 T static magnetic field. Rotation of the samples was achieved using a custom-designed sample holder consisting of a support beam loaded directly into the vertical bore of the magnet (parallel to the field direction,) outfitted with a pulley system which transferred angular velocity from a motor mounted outside of the field to a stage on the innermost pulley. For studies of nanowire alignment in solution under the rotation condition, Kapton capillaries were loaded with composite dispersion, sealed, and secured in the sample stage normal to the plane of the substrate (along the axis of rotation.) For the preparation of films, composite dispersion was spincast onto a cleaned

silicon wafer which was mounted onto the sample stage. The sample stage was then capped with a chloroform-soaked filter paper. Once the sample holder was loaded into the bore of the magnet, rotation was initiated about an axis normal to both the field direction and plane of the substrate. Alignment was performed at 16 °C which is the ambient temperature inside the magnet bore.

Preparation of aligned samples for measurements of $\chi_{\perp}$ and $\chi_{\parallel}$

10 wt. % dispersions of aqueous TAC-functionalized 10 mol % Co-doped ZnO nanowires were loaded into epoxy capsules in 100 μL aliquots and evaporated under rotation in a 6 T magnetic field (American Magnetics, Inc.) at 35 °C. Once dried, subsequent aliquots were added and the process repeated until the capsules were filled with 50-100mg of dry aligned nanowires. To prepare samples that would have nanowires aligned parallel to the vertical magnetic field during magnetic susceptibility characterization, capsules were mounted in the rotation apparatus described above with the long axis of the capsule along the axis of rotation. To prepare samples with nanowires aligned perpendicular to the characterization field, capsules were mounted with the long axis perpendicular to the axis of rotation and parallel to the aligning field.

Characterization Methods

The optical absorbance of as-synthesized 10 mol% Co-doped ZnO and non-doped nanowires was characterized using a Cary-100 spectrophotometer at 25°C, and approximate band gap was calculated by linear fitting of the squared absorption coefficient as a function of energy. Dried samples of nanowires were dispersed in ethanol and dropcast onto silicon wafers for scanning electron microscopy (SEM) imaging using a Hitachi SU-70 instrument with an accelerating voltage of 10kV. Samples were coated with a thin layer of gold-palladium to increase conductivity for high-resolution imaging. Powder XRD

patterns of 10 mol % Co-doped nanowires and non-doped ZnO wires were measured on a Bruker D-8 Focus powder diffractometer. Magnetic properties were measured with a Quantum Design MPMS superconducting quantum interference device (SQUID) magnetometer at a temperature of 16 °C. Small-angle X-ray scattering measurements were performed on a pinhole-collimated instrument (Rigaku SMAX3000) using 1.5405 Å Cu Kα radiation in-line with a superconducting electromagnet (American Magnetics Inc.) capable of producing a 6 T static magnetic field.