Luminescent solar concentrators (LSC's) are promising candidates for reducing the cost of solar power generation. Conventional LSC's are slab waveguides coated or doped with luminescence materials for absorption and guiding of light to the slab edges in order to convert optical energy into electricity via attached photovoltaic (PV) cells. Exploiting the advantages of optical fiber production, a fiber LSC (FLSC) is presented in this thesis, in which the waveguide is a polymeric optical fiber. A hybrid fiber structure is proposed for an efficient two-stage concentration of incident light, first into a small doped core using a cylindrical micro-lens that extends along the fiber, and second to the fiber ends by guiding the fluoresced light from the active dopants. Flexible sheets are assembled with fibers that can be bundled and attached to small-area PV cells. Small dimensions and directional guiding of the fibers allow for approximately one order of magnitude geometrical gain improvement over that of existing flat LSC's. In addition, the undesired limit of LSC size is eliminated in one direction.

Modeling and optimization of an FLSC design is presented using polarization-ray tracing under realistic conditions with solar spectrum radiation and broad-band absorption and emission spectra of fluorescence materials with their inevitable self-absorption effect.

Methods and results of fabrication and accurate optical characterization of such FLSC using two off-the-shelf organic dyes and a commercially available polymer, COP, are discussed in detail. Fiber preforms, fabricated under optimized conditions for low light transport loss, are thermally drawn into sub-millimeter-size fibers. Characterization of several samples with various concentrations of the two dyes shows an optical-to-optical conversion efficiency of 9.1% for a tandem combination of two 2.5-cm-long fibers with the efficiency gradually decreasing to 4.9% with increase in fiber length to 10 cm.