The universal law of gravity has undergone stringent tests for a long time over a significant range of length scale, from an atomic scale to a planetary scale. Of particular interest is the short distance regime, where modifications to Newtonian gravity may arise from axion-like particles and extra dimensions. We have constructed an ultra-sensitive force sensor based on optically-levitated microspheres with a force sensitivity of $\sim 10^{-17}$ N/$\sqrt{\text{Hz}}$ for the purpose of investigating non-Newtonian forces in the 1-100 $\mu$m range. Microspheres interact with a variable-density attractor mass made by alternating silicon and gold segments with periodicity of $\sim 50$ $\mu$m. The attractor can be located as close as $\sim 10$ $\mu$m to a microsphere. In this presentation, I describe the characterization of this system, its sensitivity, and some preliminary results. In the course of the characterization of the system and the reduction of background, substantial efforts were made on controlling rotational degrees of freedom and measuring the mass of the trapped spheres, and these are also discussed. Further technological developments to reduce background are expected to provide orders of magnitude improvement in the sensitivity, going beyond current constraints on non-Newtonian interactions. (Faculty Hosts: Yong Chen and Rafael Lang)