POLARIS: A Fiber Array Alignment System for TES Coupling

F. Malnati[1,2], S. Grandi[1,2], M. Malerba[1], E. Monticone[1] and M. Rajteri[1]

[1]*Istituto Nazionale di Ricerca Metrologica (INRiM), 10135, Turin, Italy*

[2]*Politecnico di Torino– Department of Applied Science and Technology, 10129, Turin, Italy*

Transition-Edge Sensors (TESs) are superconductive single photon detectors with photon-number resolution, where high system detection efficiency requires an optimal fiber-to -pixel coupling. Aligning fiber and TES arrays is particularly challenging due to micro-scale dimensions and the need for multi-axis positioning. In this work we present **POLARIS** (Precise Optical Line-up And Reference Imaging System), a fiber array alignment system designed to improve the precision, repeatability, and automation of TES optical coupling.

The system integrates an inverted microscope, an infrared (IR) illumination and imaging setup, and a six-degree-of-freedom hexapod positioning stage. The silicon substrate of the TES device is transparent to infrared radiation, allowing the detector structures to be visualized as shadows, while the infrared light emerging from the fiber tip appears as a bright spot in the microscope image. This configuration enables direct monitoring of the relative position between the fiber and the TES pixel during the alignment process.

Compared to the previously used manual alignment setup, the new system introduces several improvements, including full six-axis motion control, adjustable sensitivity, and the possibility to define a pivot point for controlled rotational movements of the fiber array. A dedicated Python program interfaces the hexapod controller and the IR camera to assist the alignment procedure. The software performs calibration of the image scale, automated pivot search, and semi-automatic fiber positioning by evaluating the distance between the fiber spot and the TES center selected by the user.

After the first fiber is aligned to its corresponding TES pixel, the pivot can be set on that fiber tip, allowing the rest of the array to be aligned through controlled rotations. Preliminary tests demonstrate the capability of the setup to reliably align individual fibers with TES devices, representing a key step toward full fiber-array coupling.

Future work will focus on extending the procedure to complete array alignment and further improving the automation of the process.