Liquid-nitrogen temperature stage for super-resolution 3D fluorescence microscopy

Group P

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Abstract

The objective of this project is to design a liquid-nitrogen cryo-fluorescence stage for super-resolution 3D fluorescence microscopy which is able to maintain biological samples at temperatures between -140°C and -196°C while ensuring imaging quality. The developed cryostage design consists of six essential subsystems: thermal reservoir, thermal insulation, height adjustment, sample holder, data acquisition, and vibration isolation. The design prioritizes minimizing frost formation, and maintaining temperature. Therefore, the key design considerations are the precise control of working distance between the sample and objective lens, efficient thermal insulation, and boiling vibration management. XPS foam was machined to fit into the designated area as temperature insulation.

A 3D-printed model was created before moving to the machining process to optimize the tolerance and interaction of subsystems, which ensures manufacturability and compatibility with existing microscopy setups.

The final product uses lead screws for height adjustment, a copper-based thermal reservoir for efficient cooling, and a silicone funnel for thermal insulation and vapor management. Machining processes combine CNC milling and 3D printing, balancing cost efficiency with precision fabrication. This cryostage design ensures effective thermal isolation, enhances imaging stability, and is achieved within a project budget of $3000. The design is also ready for further testing and improvement to fully optimize its performance.