Exploring alternative materials and methods for synthesizing quantum dots that are less toxic and more sustainable: HNu Photonics Preliminary Proposal

Overview of Offerings and Expertise

To conserve valuable crew time and promote the success and safety of the experiment, the research outlined in this proposal will be performed within HNu's Mobile Spacelab (MoSL) onboard the International Space Station (ISS) National Lab. An in-depth description of the MoSL facility hardware and system capabilities can be found at www.scorpiov.com. Briefly, MoSL is a hermetically sealed and automated platform for materials manufacture applications in microgravity. It utilizes up to eight independent growth chambers that are delivered fluids or material reagents at a set flow rate (typically 60 µL/min) and at prescribed time intervals throughout the course of the production process or experiment. MoSL is capable of imaging with multiple microscopy modes including epi-fluorescence microscopy, and these microscopes can be adapted to meet the needs of the PI team.

For this particular experiment, the PI team could seal the starting materials for production of quantum dots within the growth chambers, or choose to utilize the fluid reagent delivery capabilities of the MoSL platform to replenish the quantum dot growth materials from a media source bag and capture the waste materials into a waste bag for easy disposal upon payload return. The manufactured quantum dots will remain in the growth chambers. Optionally, the experimenter could choose to deliver different quantities of reagents to different growth chambers or otherwise leverage this parallelization capability to test multiple experimental parameters in a single on-orbit experiment.

MoSL is equipped with two independent microscopes, and these can each be configured to achieve different types of measurements, including fluorescence microscopy in two color channels per microscope, brightfield imaging, and other measurement modalities. For this investigation, the HNu team recommends utilizing epi-fluorescence imaging capabilities to monitor the growth of quantum dots over time. Up to two different excitation light sources could be chosen for this.

Further, HNu Photonics has expertise in hyperspectral imaging. Using HNu's FLASH spectrometry technology, microscope configurations for performing video spectroscopy on the quantum dots may also be possible (pending further discussions with the PI).

To monitor quantum dot growth, up to four sample chambers above each microscope can be scanned laterally (in one dimension) or through a focusing depth. Each chamber is approximately 1 cm to a side and 0.5 mL in volume. MoSL software includes autofocusing capabilities to scan for quantum dots through this volume.

In addition, each set of four multi-well sample chambers has its own feedback loop algorithm to maintain samples at a controlled temperature, within ±0.1°C. Optionally, the two sets of four material growth chambers could be set to different temperatures.

The MoSL platform offers investigators flexible experimental parameters to gather a comprehensive dataset for their microgravity investigations. This is helpful also in refining (and optionally adjusting in near real-time) the parameters of the material production batch. Similarly, the imaging routines will be

loaded as a nominally automated script prior to payload launch, but can be adjusted as needed via communication with the payload and ground-based command.

Each microscope can translate in one axis across the growth chambers and perform focal scans to image at different depths. The entire imaging routine of the experiment is scriptable and can be programmed for autonomous operation or user commanded input.

Summary of Services

HNu Photonics has extensive experience working with NASA to provide all payload integration documentation for the MoSL experiment supplies. The MoSL facility is launched on ISS resupply missions and designed to remain on-station for extended duration missions pending the required docking time of the resupply vehicle. During this time on ISS, MoSL will operate autonomously to execute the researcher's experimental protocol. For each MoSL mission, the SCORPIO-V team will provide full-cycle project management coordinating all required NASA processes and documentation for flight integration. The HNu team will provide further description and updated cost estimate based on the specific needs of this experiment.

Due to the stringent safety requirements of space flight and to protect the time and safety of the flight crew, HNu encourages the investigator to utilize the built-in capabilities of the MoSL facility and experience of the HNu team. MoSL is a fully contained platform that includes built-in replicates of the experiment.

Tentative Experiment Design: Quantum dot production materials will be loaded into two 4-well growth chambers prior to launch. Additional fluids/reagents will be loaded into IV bag reservoirs for automated microfluidic replacement of fluids and imaging per the PI's protocol. Once loaded, the MoSL payload will remain hermetically sealed (no air exchange with the outside environment).

The Mobile SpaceLab will operate the experiment on orbit with automated protocols, near real-time data downloading and remote operations on ISS. Samples and back up hard drives will be returned to the PI upon successful return of the MoSL facility.

Preliminary Schedule Outline The proposed research will be ready for launch within 12 months of the award date and all experiment data from this launch available within approximately 15 months of the award date pending NASA scheduling. The investigator can anticipate a tentative first launch date to be scheduled for 2024 pending SpaceX availability.

Preliminary Cost Estimate

$230,000 for a single mission with two 4-well material growth chambers delivered to the PI along with batch history records and imaging data.