Attachment 1 – DAGSI Research Topic Template

NOTE: Under the Cooperative Agreement, Technical Directorates have three options for topics. First, a topic can strictly be considered in the pool for the state allocation of funding. DAGSI will work across the TDs for this allocation. Second, the TD can be prepared to be a funding partner with the State of Ohio. This would include: providing additional funds to support additional recipients of a topic, or expand the proposers team to include additional members on a topic. Third, the TD may elect to fully fund a topic not selected for State of Ohio funding or to pursue University teams outside the State of Ohio. Contact lindsay.kotouch.2@us.af.mil for questions.

1. **Research Title:** Advanced Packaging Solutions for mm-W RFIC and MMIC
2. **Individual Sponsor:**

Mr. Trevor Dean, AFRL/RYDI
2241 Avionics Circle Bldg 600
WPAFB, OH 45433-7333
Phone: 937-713-8894
Trevor.Dean.3@us.af.mil

3. **Academic Area/Field and Education Level:** Electrical/Computer Engineering (MS or Ph.D. Level)

4. **Objectives:** Design and test millimeter-wave (mm-W) radio frequency integrated circuits (RFIC) and monolithic microwave integrated circuits (MMIC) that leverage advanced packaging techniques to improve performance.

5. **Description:** The increasing demand for high-bandwidth and high-resolution capabilities in future Air Force systems necessitate operation in the mm-W frequency domain, particularly within the V (40-75 GHz) and W (75-110 GHz) bands. However, conventional circuit design and packaging methodologies prove inadequate at these frequencies, exhibiting significant performance degradation due to dielectric losses and material discontinuities arising from mismatched impedances and suboptimal substrate properties. This research explores advanced packaging paradigms, specifically 2.5D and 3D heterogeneous integration (HI), to mitigate these limitations. By enabling the co-integration of diverse active and passive materials with optimized electrical properties, HI offers a pathway towards achieving superior mm-W circuit performance [1]. Underscoring the criticality of this research area, the DARPA Next Generation Microelectronics Manufacturing (NGMM) program [2] aims to expand the HI manufacturing base, paving the way for significant improvements in cost, size, weight, and power (C-SWaP) for future Air Force systems. This research will focus on developing robust co-design methodologies that encompass both circuit and package elements, leveraging advanced electromagnetic simulation tools to ensure first-pass design success and minimizing costly design iterations. This holistic approach is crucial for realizing the full potential of 2.5D and 3D HI solutions for future mm-W applications. A strong foundation in mm-W circuit design principles and familiarity with the packaging design flow are essential. Proficiency with industry-standard design and

simulation tools such as Cadence AWR & Virtuoso, Keysight ADS, Ansys HFSS, and Altium PCB software is highly recommended.

[1] J. A. Estrada, G. Lasser, M. Pinto, F. Herrault and Z. Popović, "Metal-Embedded Chip Assembly Processing for Enhanced RF Circuit Performance," in *IEEE Transactions on Microwave Theory and Techniques*, vol. 67, no. 9, pp. 3537-3546, Sept. 2019, doi: 10.1109/TMTT.2019.2931010.
[2] M. Holmes, S. Woodruff, C. Ryder, “The Defense Advanced Research Agency’s (DARPA) Next Generation Microelectronics Manufacturing (NGMM) Program,” presented at Compound Semiconductor Manufacturing Technology Conference, New Orleans, LA, USA, from May 19-22, 2025.

6. **Research Classification/Restrictions:** Unclassified / U.S. Citizenship Required
7. **Eligible Research Institutions:** Universities (DAGSI)
8. **PA Approval #: AFRL-2025-3669**

NOTE: Topics submitted to DAGSI must be approved for public release.