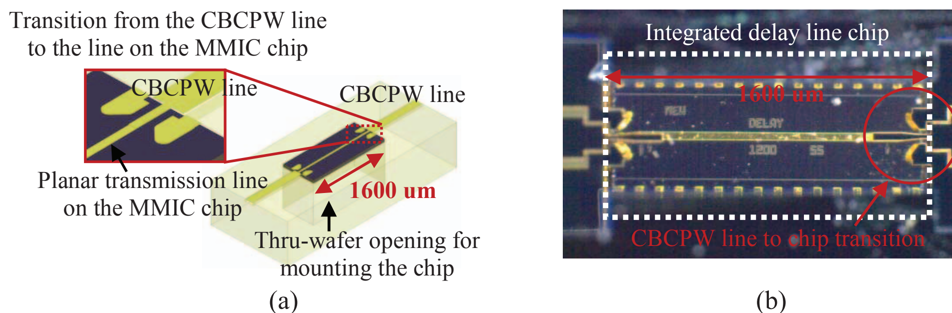
An In-line Chip Integration and Packaging Method for Millimeter- and Sub-Millimeter-Wave Band Applications

Armin Jam, Jack East, and Kamal Sarabandi*
Radiation Laboratory, Department of Electrical Engineering and Computer Science,
University of Michigan, Ann Arbor, MI, 48109, USA

In this paper a novel chip integration and packaging methodology for millimeter-wave (MMW) to sub-terahertz (THz) band (100GHz-1000GHz) is demonstrated. This is in contrast to the conventional E-plane probe integration method which has been the only reliable method of transitioning from coplanar or microstrip lines on active MMIC to waveguides for connecting to other active and passive components of the system. One or both ends of lines on MMICs are extended and suspended in rectangular waveguides to act as E-plane probe. The drawback of this approach is the complex 3-D geometry of the transition which requires complicated machining fabrication process with assembly of various parts, which is expensive. To overcome this problem, the proposed integration method is designed to be part of a low cost micromachined system that will allow low cost, high performance fabrication. The proposed method is based on a peg and socket approach with a simple transition from the line on the MMIC chip to the fabricated lines on a packaging block. In order to enable scalability to up to the THz regime, the transition and the mounting block are designed to be compatible with silicon micromaching technology which offers a standardized fabrication process with very high accuracies.

Fig. 1(a) illustrates the configuration of the proposed peg and socket integration method where the line and pads on the MMIC chip mate the lines and pads on the wafer. The socket is micromachined in the wafer and has the exact dimensions of the active chip (peg) with extended membranes to support the lines and pads on the wafer. The lines on the wafer are then transitioned to waveguide using a recently developed grounded-CPW line to waveguide transition. Metalized micro-cylindrical bumps are also fabricated on the pads and lines to enhance the contact between the traces on the wafer and those of the MMIC chip. In order to validate the performance of the proposed integration methodology a prototype is designed and microfabricated at J-band [Fig. 1(b)] and excellent measured performance is reported in the desired frequency range (220-260 GHz). The new method is a strong candidate for a standardized integration and packaging technique at MMW to THz frequencies and is expected to find a wide range of applications in this area due to its scalability, low cost, compact form-factor and superb RF performance.



(a) (b)

Fig. 1. (a) Diagram of the proposed peg and socket integration and packaging method. The chip (purple) is mounted in the thru-wafer opening and the traces on the chip and traces of the CBCPW are overlapping. (b) Close up of the micromachined prototype of the packaging block at 240 GHz.