Heterogeneous Integration/Advanced Packaging

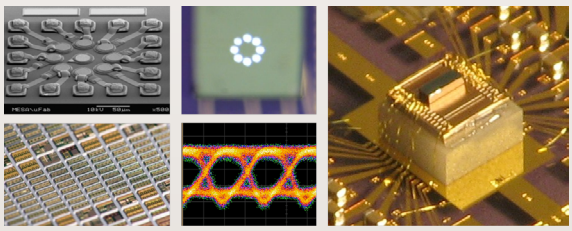
Enabling Photonic/Electronic Microsystems

Sandia National Laboratories has developed several state-of-art hybridization capabilities to enable prototyping of high performance electronic, optoelectronic and MEMS microsystems for national security applications. Intimate integration of dissimilar materials enables the use of optimized photonic devices, optical elements, MEMS sensors/actuators, and electronic circuitry while improving overall component size, weight, and performance, compared to conventional packaging approaches.

Heterogeneous integration processes leverage the Sandia MESA complex, a 65,000 sq. ft. production/R&D facility with extensive Si and III-V microfabrication tool sets. Relevant integration methods range from wafer bonding of materials to precision flip chip assembly of devices and materials for subsequent processing. Microsystems targeting a wide range of applications have been demonstrated, combining materials such as silicon, InP, GaAs, GaSb, GaN, AlN, diamond, and glass.

Optical Data Communications for High Performance Computing

- GaAs- and InP-based VCSELs, modulators, photodiodes
- Dense integration onto 32-nm and 45-nm CMOS
- Silicon photonics on high-speed silicon ASIC
- Independent optimization of electronics and photonics

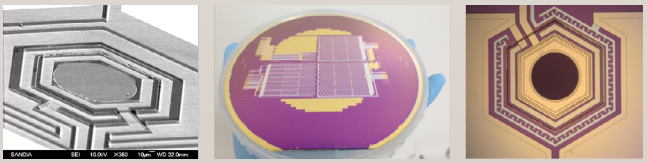


IR Imagers for Remote Sensing

- GaSb-based MWIR/LWIR detector arrays for large-format FPAs
- 10 µm indium bump bonding, underfill, thinning, AR coating
- Hybridization to silicon ROICs with >99.99% interconnect yield

Microsystem-Enabled Photovoltaics

- Wafer-level bonding for multi-junction solar cells
- InGaAsP/InP and InGaP/GaAs devices on silicon
- Dielectric interfaces with III-V substrate removal
- Integration with collection optics

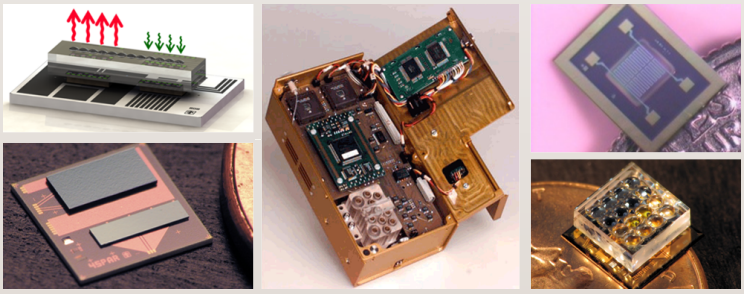


Heterogeneous III-V/CMOS Microelectronics

- Complementary integration of GaAs and InP microelectronics
- III-V microelectronics circuitry on CMOS ASICs

Optical and MEMS-based Microsensors

- Chemical and biological sensors using MEMS and SAW devices
- G-hard optical microsensors with in-house photonics
- Hybrid device integration with custom micro-optics



Extreme Environment Applications

- Custom photonics, optics, and electronics for cryogenic interconnects
- Advanced optoelectronics and integration for radiation hardness
- High-power emitters on AIN and diamond
- RF packaging for high-speed test and measurement

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Advanced Packaging

The development of enabling photonic/electronic microsystems requires more than the invention of new and unique devices and structures. These devices must be individually packaged and interconnected to function together as an integrated system that can communicate effectively with the macro external world. One must understand the application requirements to anticipate and address a number of multidisciplinary engineering challenges. To maximize chances of success, packaging, assembly, and integration should be considered as early as possible.

Sandia staff members have many decades of experience developing not only first-of-a-kind R&D devices, but also high-reliability devices for space and national defense applications, as well as commercial products. Just a sample of recent and current projects includes high-speed, high-resolution X-ray cameras, remote sensors for space deployment, a variety of quantum devices operated at cryogenic temperatures, and autonomous chemical microsensor systems. We can help evaluate a variety of packaging and integration options, anticipating and addressing manufacturability, rework, thermal management, and materials compatibility issues. Strategic partnerships within Sandia as well as with other national laboratories, universities, and private industry enable the development and implementation of advanced microsystems packaging solutions with the greatest value.

Trusted Packaging Capabilities

Seal and Encapsulation

- Hermetic ceramic packaging
  - Solder lid seal
  - Parallel seam sealing
- Glob top
- Dam and fill

Packaging and Assembly Design/ Development

- Package design and selection (ceramic and plastic substrates)
- Thermal management
  - Materials selection and evaluation
- Packaging and assembly process development
- Full custom microsystems integration

Custom Packaging and Assembly

- Multi-chip modules
- Thermo-compression bonding
  - Die-to-die, wafer-to-wafer, and die-to-wafer
- MEMs packaging and assembly
- RF assembly
- Optoelectronic assembly
- Flex circuit assembly
- Surface mount assembly
- Rework and repackaging

Dicing

- Die singulation
- MEMs dicing
- Dicing of
  - Si, glass, quartz, and various ceramics and organics
  - Up to 200 mm wafers
  - Thinned wafers
  - Multi-project wafers

Packaging Technologies

- ISO 9001 registered high-reliability ASIC packaging
- Hermetic ceramic and plastic high reliability packaging (all standard configurations)
- RF and optoelectronics packaging
- MEMS packaging
- Flex and surface mount assembly
- Rapid hybrid microsystems prototyping
- Ultra-miniaturization (3-D packaging and 3-D Integration)

Die Attach

- Manual and automated, precision die placement
- Conductive and nonconductive organic (epoxy) die attach materials
- Eutectic die attach

Wire Bonding

- Manual and automated wire bonding
- Aluminum and gold wire
  - Wedge and ball bonding
- Fine pitch (down to 50 um)
- High wire count
- Wire bonding to ceramic, organic and metal packages

Flip Chip Assembly

- Eutectic and high Pb solders
- Au stud bumping (wafer or die)
- Plastic and ceramic substrates
- Precision underfill dispensing

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