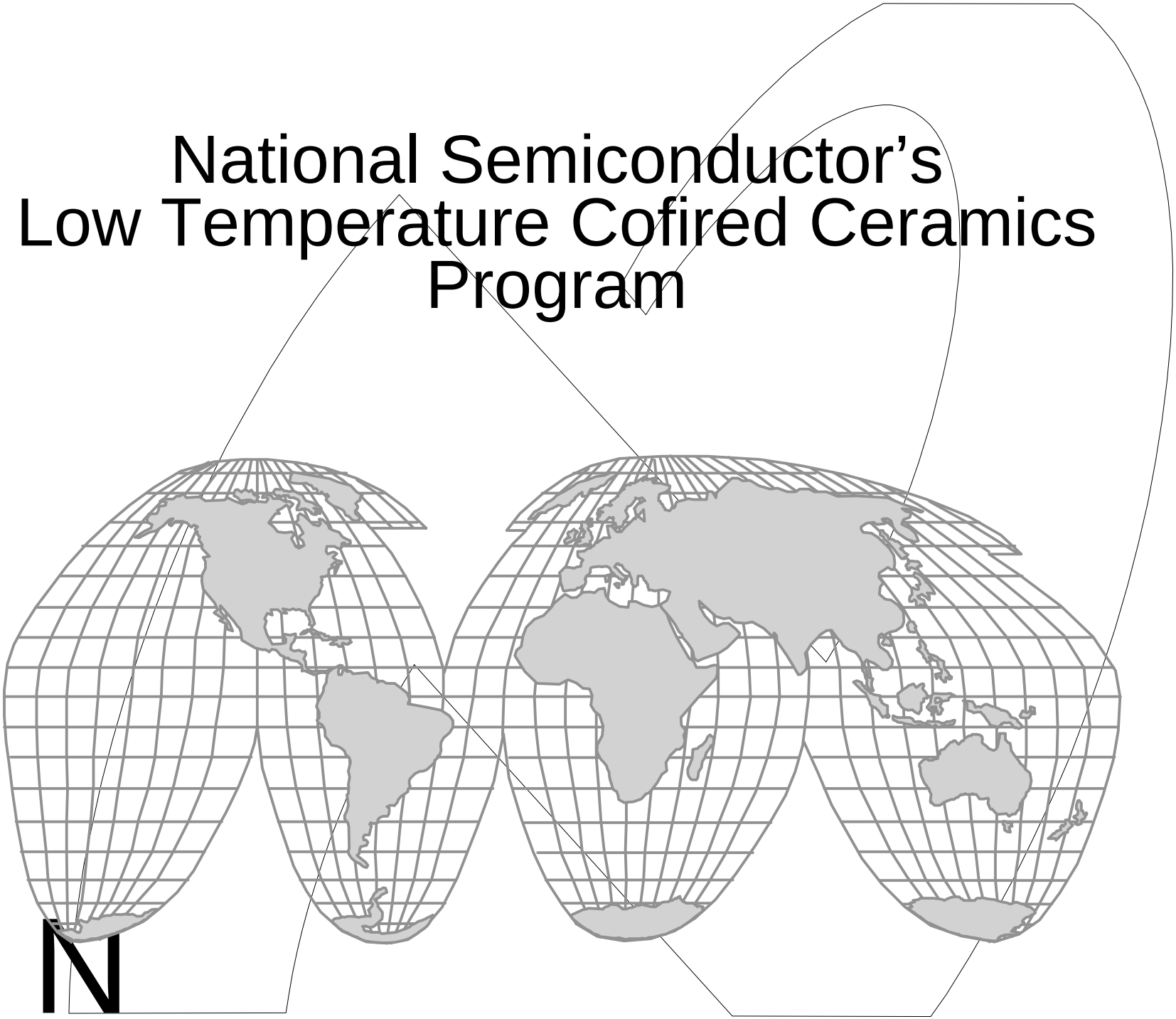
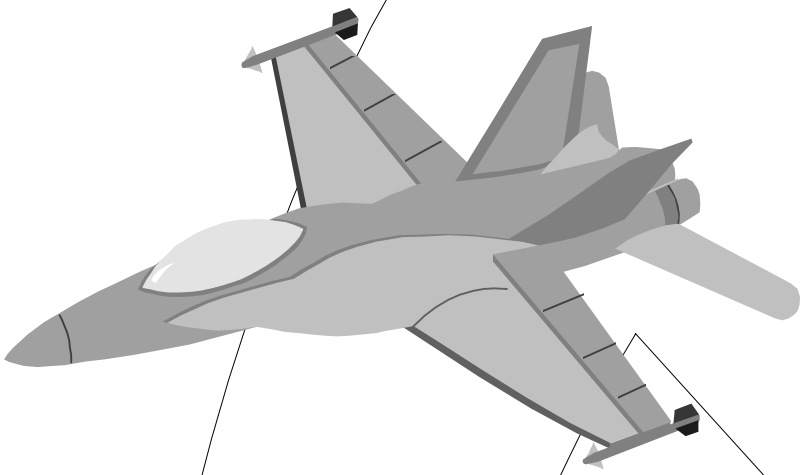
National Semiconductor's Low Temperature Cofired Ceramics Program



Historical Perspective



- LTCC was originally developed by Hughes for MIL systems
- National acquired the manufacturing line, licensed the technology, & hired key personnel from Hughes in Aug.. 1995

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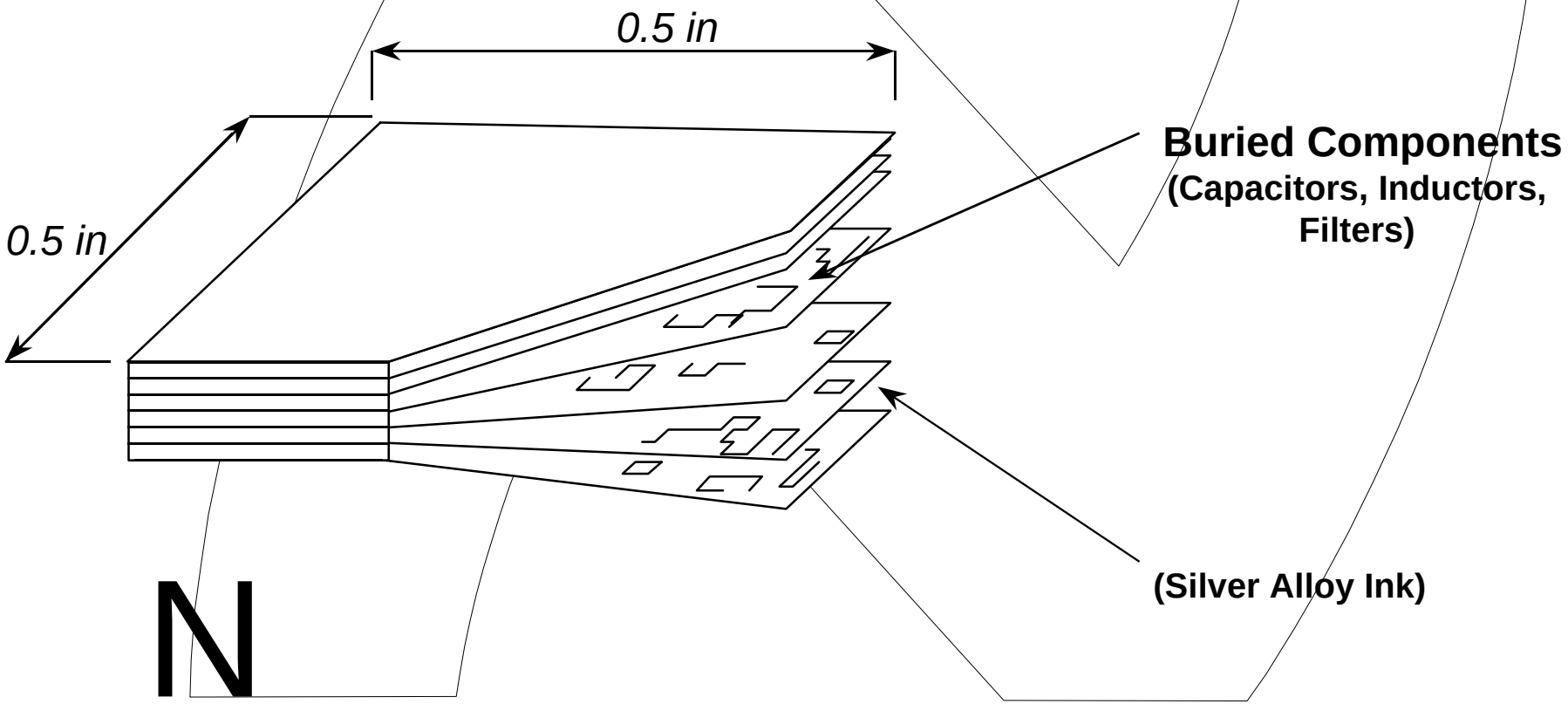
Low Temperature Co-Fired Ceramic

LTCC is a Process Technology which allows RF engineers to create Passive components in the LTCC substrate:

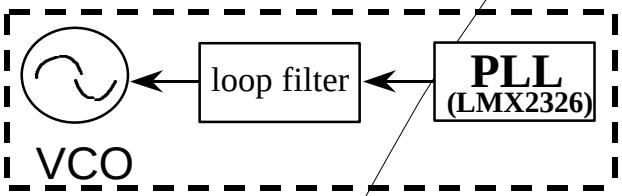
- Silver and Gold metal alloys are printed onto selected layers of the substrate
- Each layer is a ceramic composite with very stable dielectric properties
- Low-Temperature process allows for the use of highly conductive metals (AG, AU)

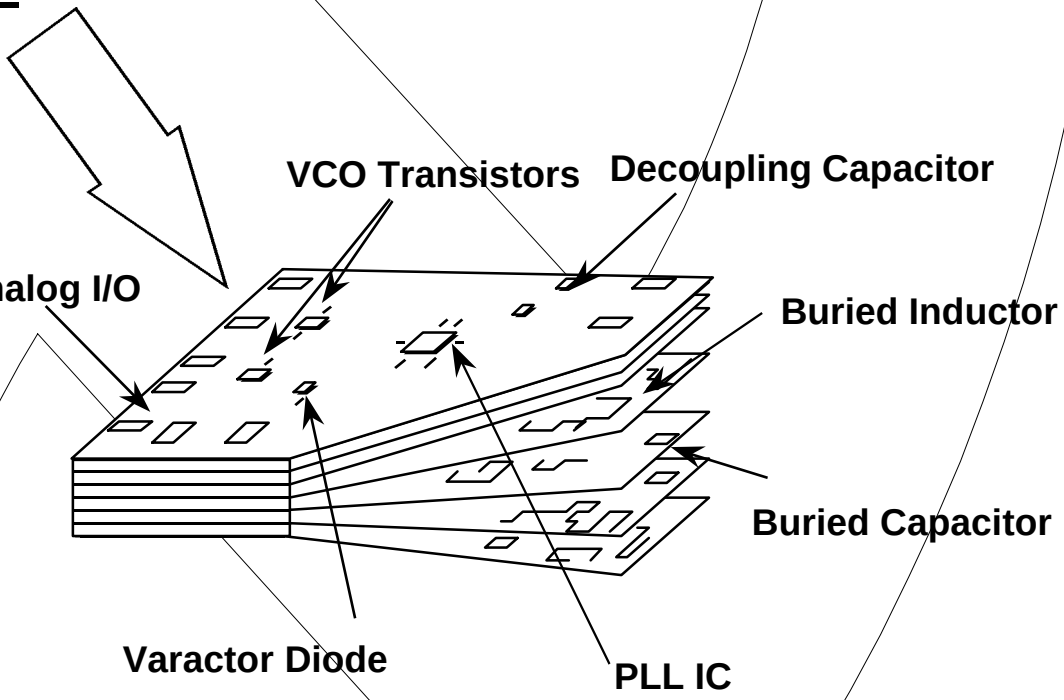


What is LTCC?

Ceramic technology used to create passive circuit elements such as capacitors resistors & inductors

Synthesizer Module





Compliments silicon integration with embedded passives

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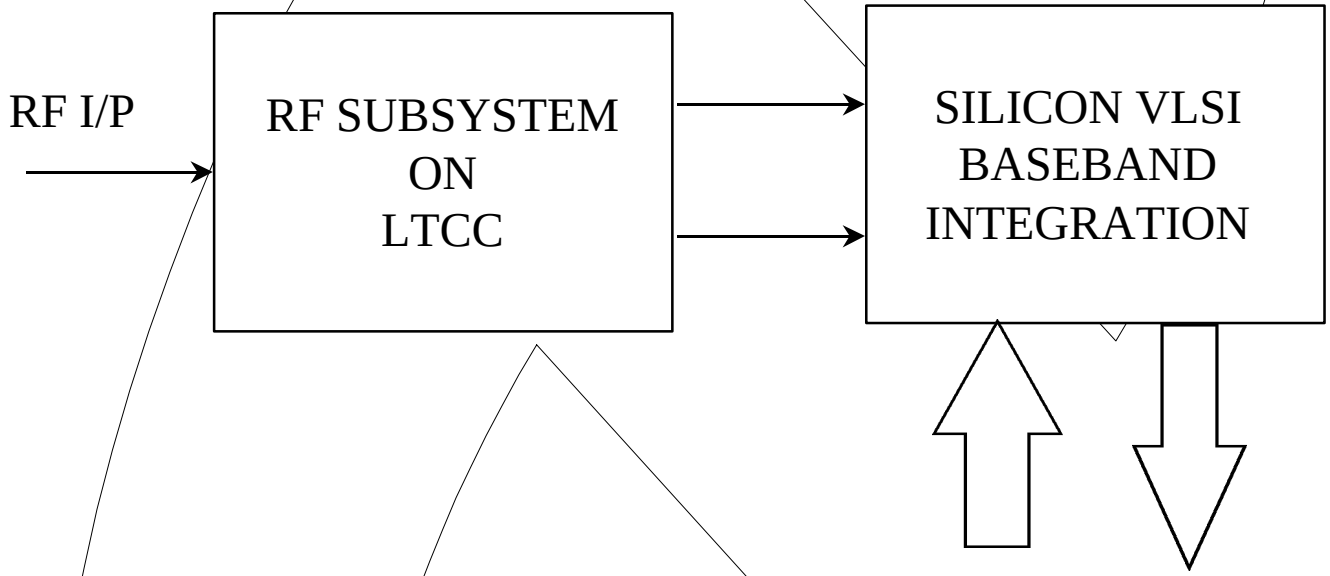
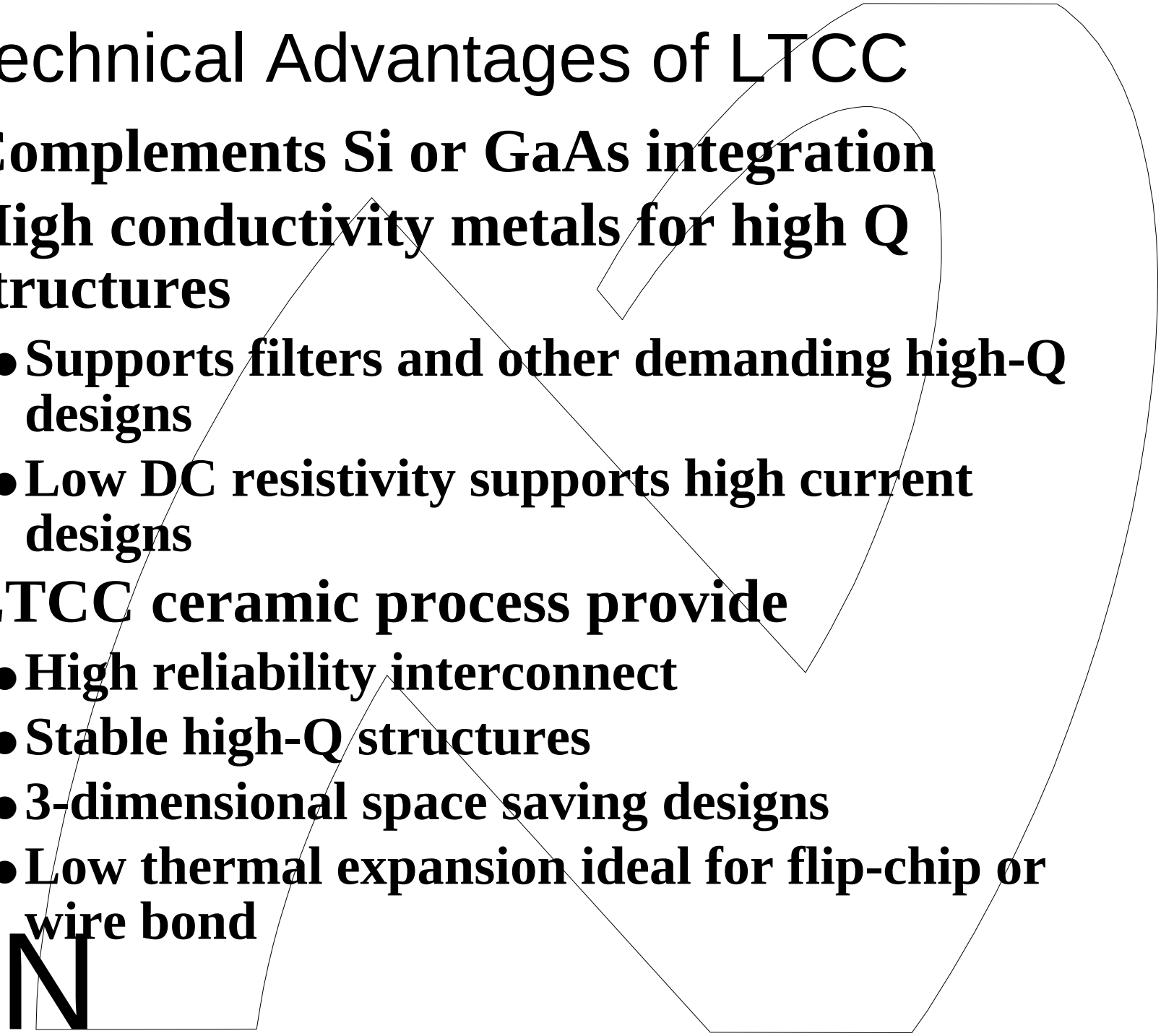
Complimentary to Si. Integration

- LTCC complements Silicon integration to provide “RF system-on-a-chip performance, not possible with Si alone



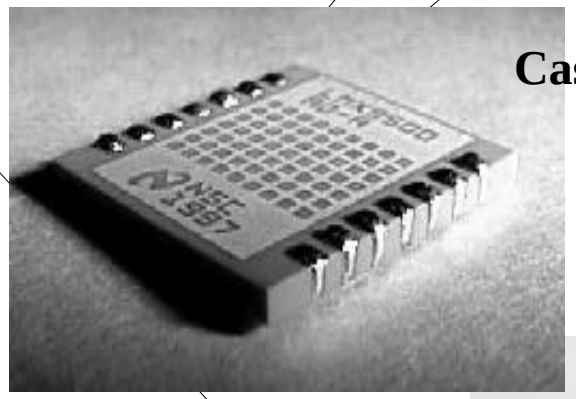
Technical Advantages of LTCC

- **Complements Si or GaAs integration**
- **High conductivity metals for high Q structures**
  - **Supports filters and other demanding high-Q designs**
  - **Low DC resistivity supports high current designs**
- **LTCC ceramic process provide**
  - **High reliability interconnect**
  - **Stable high-Q structures**
  - **3-dimensional space saving designs**
  - **Low thermal expansion ideal for flip-chip or wire bond**

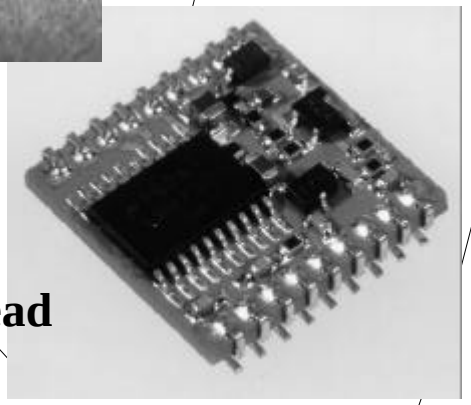


Package Styles

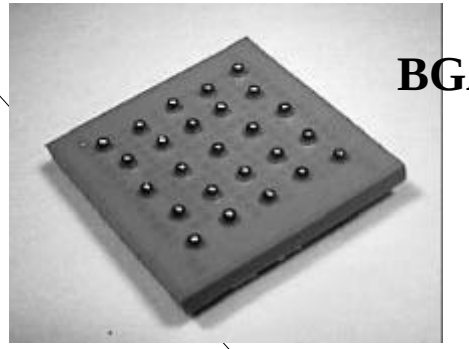
- **Castellated**
  - ➔**Most recent development**
  - ➔**Best RF performance**
  - ➔**Lowest cost**
  - ➔**Qualification - July 1998**
- **Clip lead**
  - ➔**Backward Clip lead**
  - ➔**Backward compatible**
  - ➔**Good mechanical strength**
  - ➔**Medium cost**
- **BGA**
  - ➔**Standard footprint**
  - ➔**Good mechanical strength**
  - ➔**Medium cost**



Castellated



Clip lead



BGA

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Summary

- Recent advances in LTCC materials technology enables many RF structures to be embedded in ceramic substrates saving size, weight and cost
- Direct chip-on-substrate silicon IC’s and discrete devices can provide superior electrical and thermal performance
- Many discrete passive devices can be effectively eliminated completely by substrate integration