In advanced packaging, Professor Chappell's research group is attempting to expand the role of vertical integration in high frequency circuits. He has two DARPA-sponsored projects which are focused on vertical integration of packaging for high frequency communications (satellite and terrestrial). In addition, he has garnered industrial attention through the integration of ceramic multilayer circuits with less traditional integrated circuit techniques for the development of commercialized vertically integrated circuits.

Through this work, he has been able to establish an advanced packaging laboratory garnering large equipment donations from industry to create a Low Temperature Cofire Ceramic (LTCC)/ organic board packaging laboratory. This laboratory will be tangential to the work done in the Birck Nanotechnology Center and allows for full system level solutions at a packaging level supporting the more traditional wafer-based work found in most solid state/MEMS laboratories. This laboratory has provided the group with a unique area in high frequency circuits and will be the basis for his research for years to come in the high frequency circuit arena. One area of interest within the advanced packaging laboratory has been the demonstration of multilayer laser-based processing for micro and millimeter wave circuits. Vertically integrated circuits with hundreds of rapidly deposited polymer layers allows for novel three-dimensional designs never before demonstrated. More traditional approaches are brazed on multi-layer ceramic and organic packaging.

The LTCC Fabrication Lab is a fully capable product development area. From network design to final element, the students and staff have the talent and tools to push beyond industry-edge designs. Enlisting local talent, Prof. Chappell’s IDEAS group has employed three former engineers from CTS Microelectronics, bringing over 75 combined years of microelectronics industry experience to the laboratory, including more than 50 combined years of LTCC fabrication and packaging experience. The lab also has collaboration with local design and assembly companies when industry experience in product design and prototyping is required.

The microelectronics fabrication lab is where much of the design and fabrication for our research group occurs. It has a wide range of tools available for use. This includes machines for LTCC assembly such as screen printers, precision punch, inspection stations and several ovens. It also contains a stereolithography machine which is used to form arbitrary 3 dimensional shapes out of polymer. These parts can then be metallized and used as antennas, resonators, or ion traps. There is also a milling machine that can be used to fabricate large scale planar circuits as well as patch antennas and similar device. This lab also contains several computers that are used for simulations.

The laboratory’s LTCC fabrication capabilities include:

- product/network design
- translation of design files
- screen and stencil file generation
- material pre-conditioning
- material punching (via hole generation)
- via-fill and conductive trace print
- vacuum seal and isostatic lamination
- complex cavity and shape creation
- organic burnout and sintering
- product singulation
- inspection and measurement
- package/braze/component attach
Precision Punch Machine - LTCC Via Generation
MPM TF-100 Printer/Screen - Via Fill/Pattern Print
Precondition/Bake Oven
Micro-Inspection Station
Multi-Layer View
Lamination Stack
Vacuum Seal / De-Gas Station
Bagged for Lamination
Isostatic Press
Soft Media Milling Machine
Sintering Furnace
Maskless Lithography
FinePlacer Flip Chip Assembly
3D-SLA Machine
UV Exposure Station
Characterization Lab
Test Equipment
Examples of Advanced Manufacturing for RF and Microwave Components

Three-dimensional Antennas and Sensors
> 500 layers of polymer to create metallized 3-D replicas of Ansoft HFSS Drawings for functional microwave components

Metallized Ultrawideband Horn Antenna
Microwave Waveguides, Filters, and Coax Transitions

Multi-layer Polymer Ion Traps
Chemical sensors with trace detection capability through applied RF fields by the creation of 3-D polymer/metal systems

Single Multilayer Ion Traps (Nanoform Polymer)
Arrays of Sub-millimeter Multilayer Ion Traps

Embedded Components and Multilayer LTCC Packages

Embedded Capacitors
K’s greater than 1500
Biomedical Application
High-Valued Inductors and Buried Components
Complete Satellite Radio on 15 layer LTCC Substrate Components

Organic Antenna Array Panels and Packages – LCP, Fr-4, and Duroid