MCL BOOTCAMP

ANATOMY OF A PCB & PCB MATERIALS

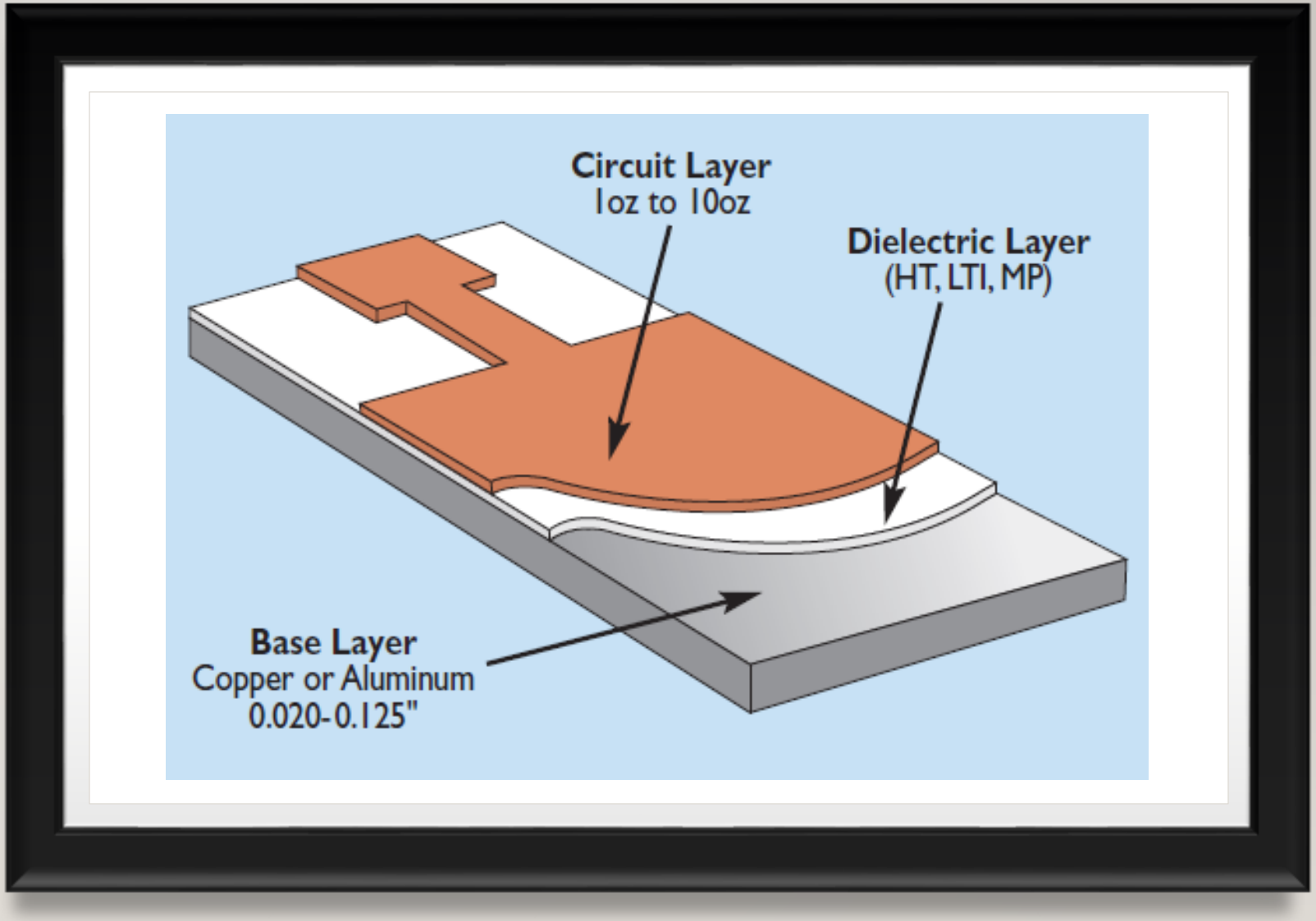
ANATOMY OF A PCB

- Base – thin board of insulating material, rigid or flexible, which supports all conductors and components
  - Provides mechanical support to all copper areas and all components attached to the copper
- Conductors – normally of high purity copper in the form of thin strips of appropriate shapes firmly attached to the base material
  - Provides the electronical connections between components and solderable attachment points

WHAT IT TAKES TO MAKE A PCB

- Laminate – a flat, rigid product made by bonding two or more layers of material
  - Obtained by pressing layers of a filler (reinforcement) material impregnated with resin under heat and pressure
  - The epoxy glass in the middle serves as an insulating material and provides the structural strength for mounting components
- Prepreg – a sheet of woven glass reinforcement impregnated with a resin that is not fully cured yet
- Metal foil – usually copper is used
  - The copper foil on the outside is the conductive medium through which electrical currents travel

WHAT IT TAKES TO MAKE A PCB



RESINS

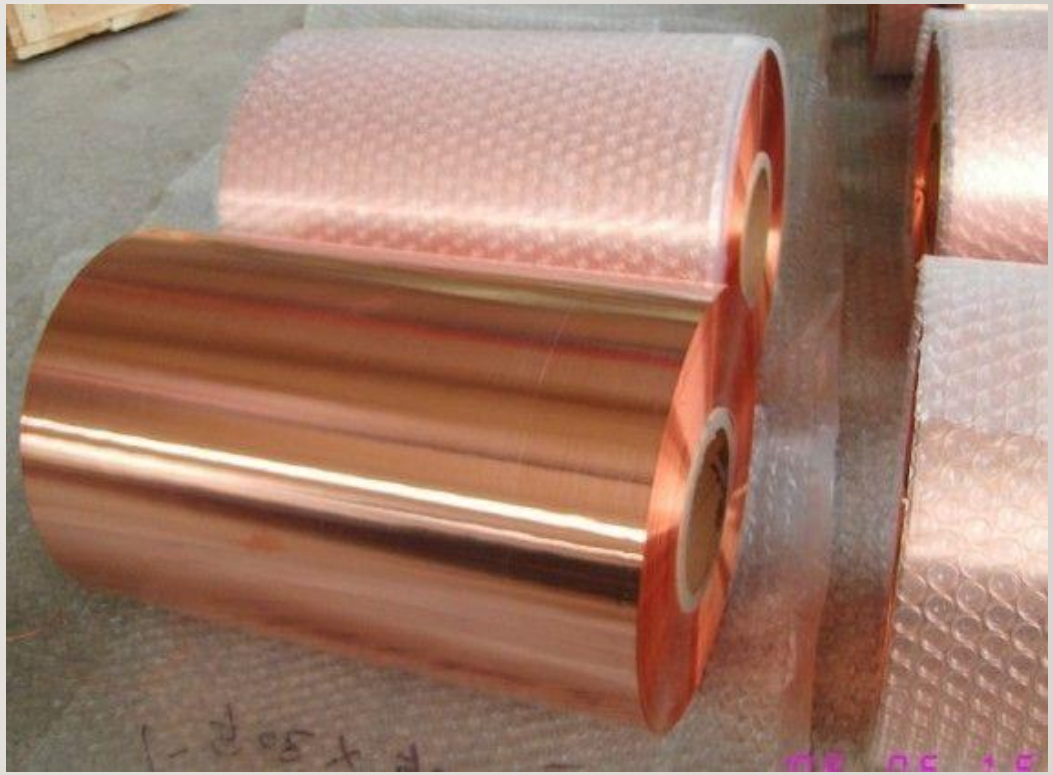
- How is a resin selected?
  - Electrical, mechanical, chemical, and thermal characteristics are taken into account
  - All have varying degrees of importance depending on the specific application of the PCB
- Epoxy resins are the most commonly used and sometimes modified with additives to achieve higher thermal properties or improved chemical resistance
- Polyamide is the material of choice when extreme thermal conditions exist, such as extended time at high temperatures during assembly or use

METAL FOIL

- The conductive layer on a laminate can be made of:
  - Copper
  - Nickel
  - Stainless steel
  - Beryllium copper
- Copper is most widely used due to availability, cost, and functionality
- Copper cladding can be on one side of the board or both, depending on the need and use

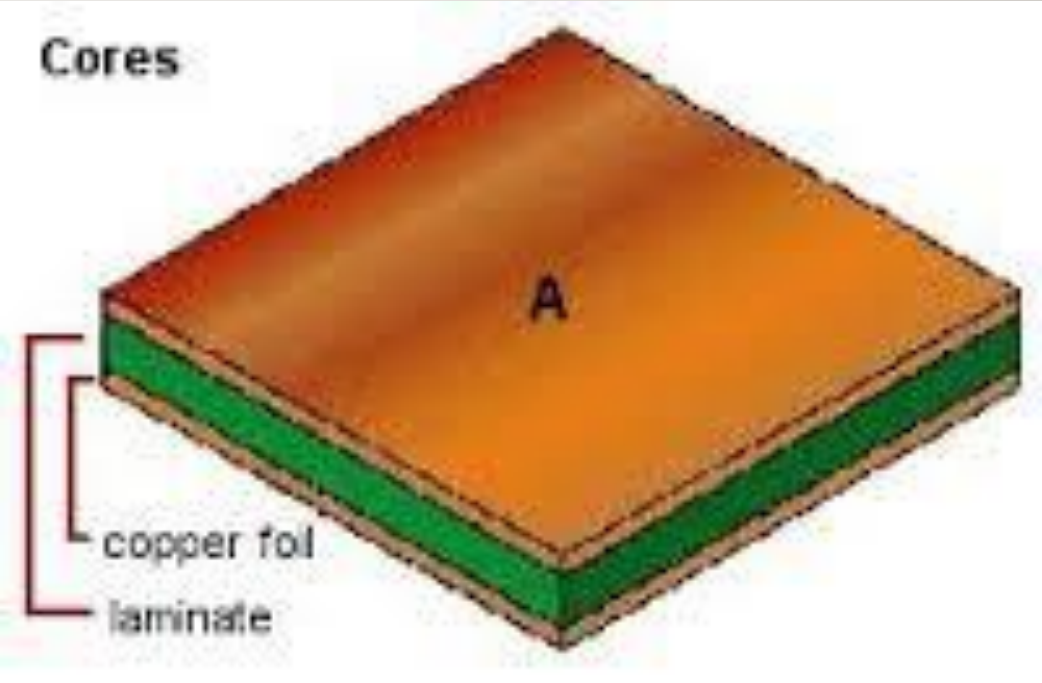
COPPER FOIL

- The quality of the PCB depends to a large extent, on the properties of the copper foil
- Available in two forms:
  - Rolled annealed copper foil
  - Electrolytic copper foil



LAMINATES

- IPC-4101 – Specification for Base Materials for Rigid and Multilayer Printed Boards
  - Current laminate specification
    - Defines the electrical, mechanical, chemical, and environmental requirements that the various combinations of reinforcement and resin (laminate) must meet

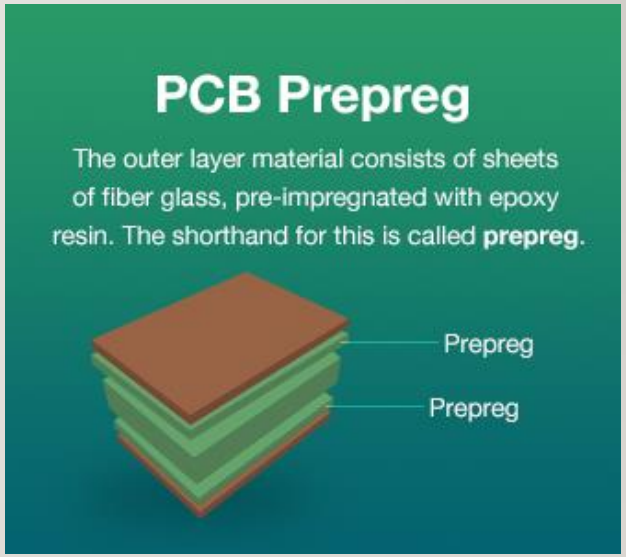


LAMINATES….ALSO KNOWN AS DIELECTRIC OR SUBSTRATES

- Varying cloth weaves, cloth thickness, and resin percentage are used to achieve the desired final thickness and dielectric characteristics
- The cloth or fiber material, type of resin, and the cloth to resin ration determine the laminate's type designation
- Important characteristics:
  - Level to which the laminate is fire retardant
  - Dielectric constant
  - The loss factor – signals, structure
  - Tensile strength – the resistance of a material to breaking under tension
  - Shear strength – the strength of a material against the type of structural failure where the material fails
  - Glass transition temperature (Tg) – the temperature region where the polymer transitions from a hard, glassy material to a soft, rubbery material
  - Z-axis expansion coefficient – the z-axis is the through-plane direction; as the temperature increases, expansion in the Z direction should be a low as possible

PRE-PREG MATERIALS

- FR-2 – phenolic cotton paper
- FR-3 – cotton paper and epoxy
- **FR-4 – woven glass and epoxy** **most common**
- FR-5 – woven glass and epoxy
- FR-6 – matte glass and polyester
- G-10 – woven glass and epoxy
- CEM-1 – woven glass and epoxy
- CEM-2 – cotton paper and epoxy
- CEM-3 – non-woven glass and epoxy
- CEM-4 – woven glass and epoxy
- CEM-5 – woven glass and polyester



KEY SUBSTRATE PARAMETERS

- Woven reinforcements are cheaper, but the high dielectric constant of glass may not be favorable for many higher-frequency applications
- Non-woven reinforcements, or materials with low or no reinforcement, are more expensive but more suitable for some RF/analog applications
- Key parameters:
  - Thermomechanical (glass transition temperature, tensile strength, shear strength, thermal expansion)
  - Electrical (dielectric constant, loss tangent, dielectric breakdown voltage, leakage current, tracking resistance,…)
  - Moisture absorption

FR-4 (CONTINUED)

- Well-proven, properties well understood by manufacturers
- Very common, workhorse of the industry
- Several grades with somewhat different properties are available
- Typically rated to 130° C
- Thin FR-4 can be used in bendable circuit boards

TEFLON

- Teflon is reinforced with glass fiber to get a laminate of low dielectric constant
- Used in RF (radio frequency) applications with small leadless components
- Due to high coefficient of thermal expansion, Teflon laminates have limited use

ALUMINUM OR METAL CORE BOARDS

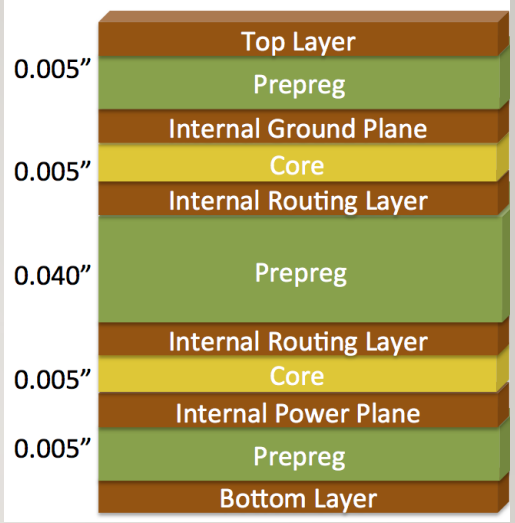
- Used for parts requiring significant cooling – power switches, LEDs
- Consists of usually single, sometimes double layer thin circuit board base
  - FR-4 laminated on an aluminum sheet metal

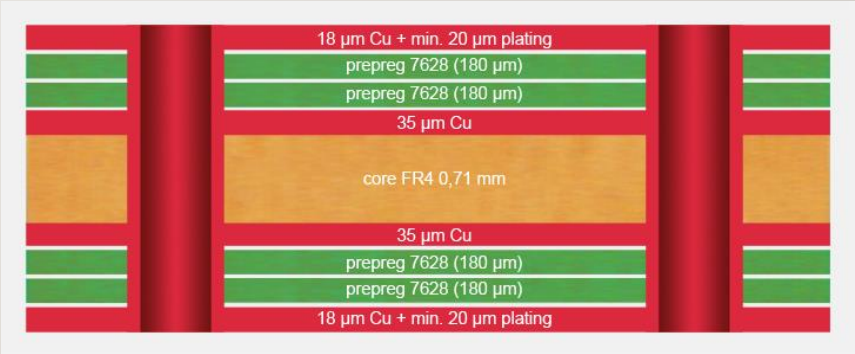
PROPERTIES OF LAMINATES

- Electrical and mechanical properties affected by environmental factors:
  - Humidity
  - Temperature
  - Corrosive atmosphere

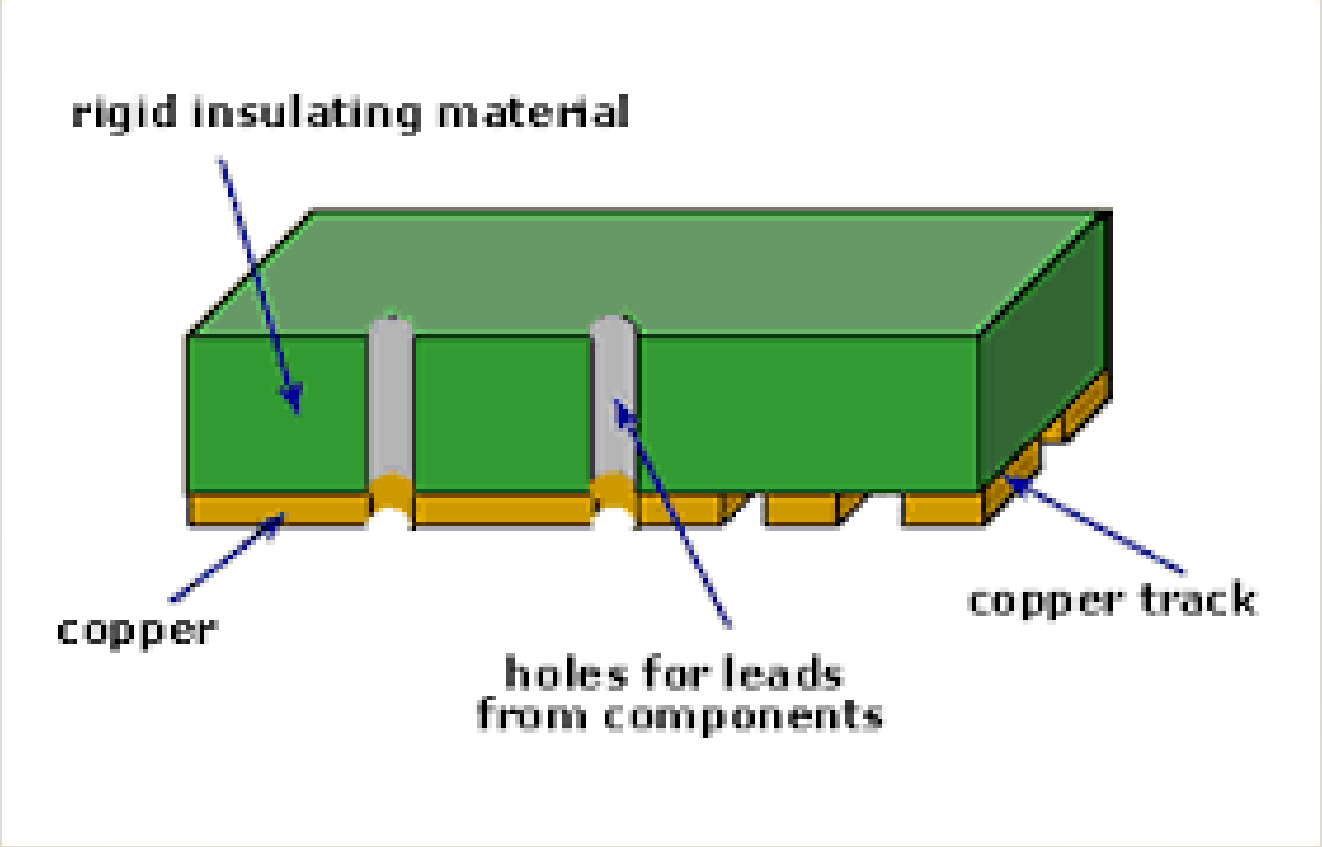
CORES

- Circuit board cores are pre-pressed layers
  - Copper foil –dielectric – copper foil
- can vary from 0.005” to 0.060” thick
- The number of cores used will depend on the board’s design

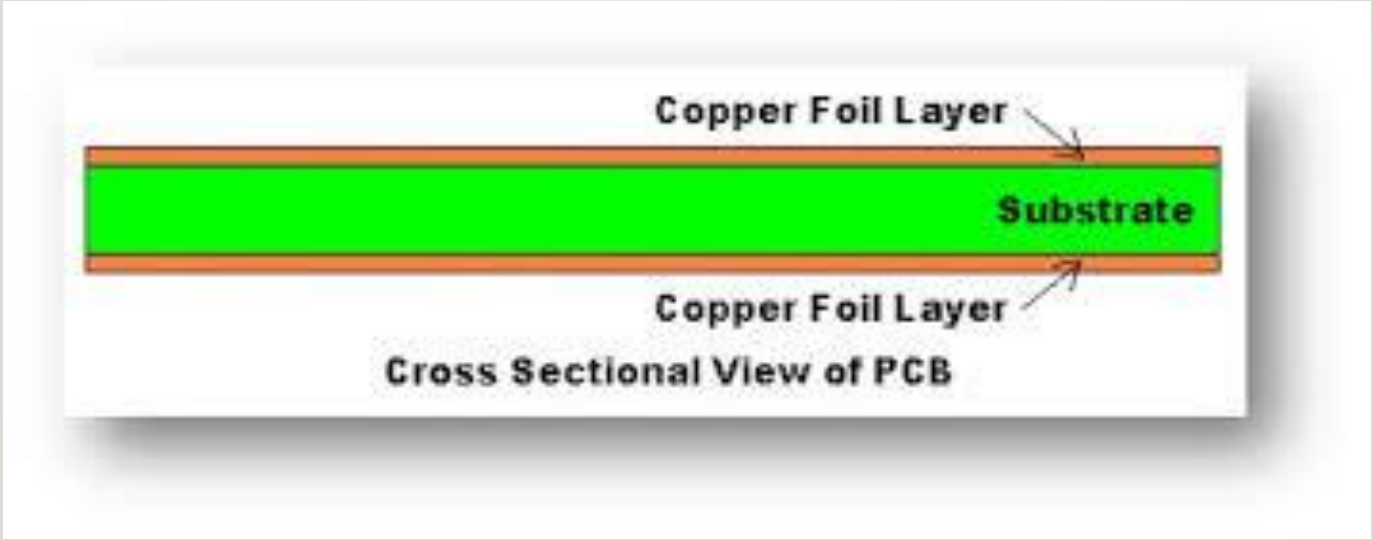




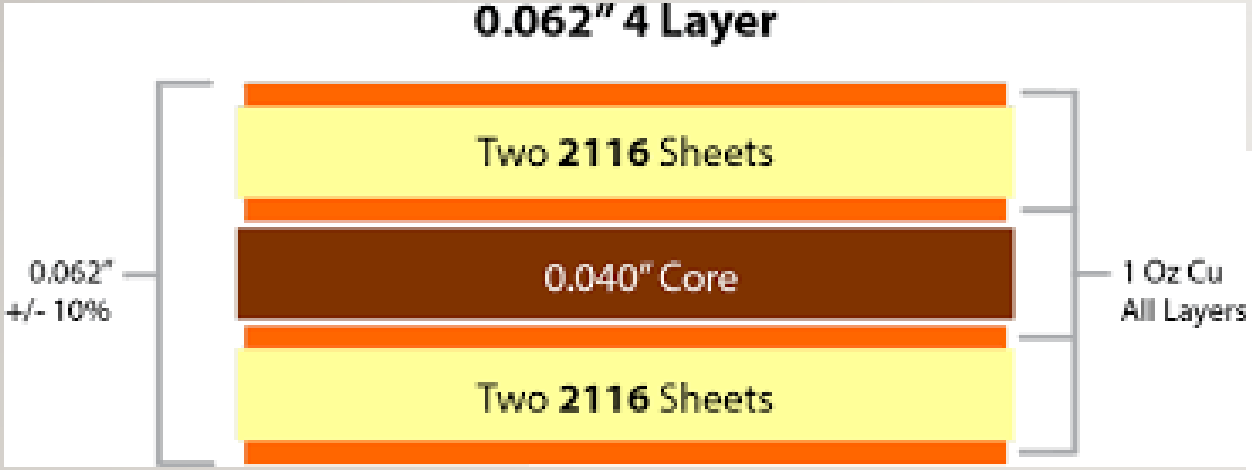
ANATOMY OF A SINGLE-LAYER PCB



ANATOMY OF A DOUBLE-SIDED PCB



ANATOMY OF MULTILAYER PCBS



Questions

Thoughts

Ideas