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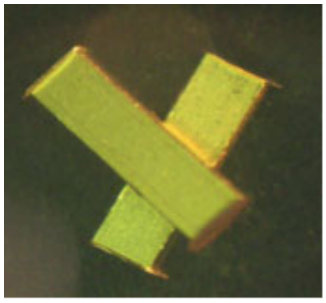
## Material Information



## Material Information

Kadco will help with all your material concerns- starting at material selection. We work with a variety of substrate materials like alumina, plastic, and quartz to produce products mainly for the electronics, optics, optoelectronics, and photonics industries. We offer these materials in a variety of sizes and thicknesses (Please contact us for exact material specifications). We have experience machining all types of materials, particularly very hard ones like garnet, since we have developed specialized techniques over time. We machine accurately to avoid chipping and maintain proper adhesion of metal on the surfaces.

We encourage you to discuss your project with us early on to avoid difficult problems later on. We will convey the benefits as well as tradeoffs of each material and discuss various processing techniques used to manufacture your product. We strive for the highest quality and will help reach a cost effective solution to your problem. We look forward to discussing your unique requirements.



### ALUMINA ($AL_2O_3$)

- Crystalline material that is white in color
- Often used as a raw material for ceramic products
- Comes in 3 common forms for dicing:

**99.6% alumina** is the purest form and the hardest. It is normally used for thin film microwave circuits operating at high frequencies because it can be polished to a 1 microinch or better surface finish. This lets the circuit designer obtain precise values for thin film resistors such as tantalum nitride (TaN) or nichrome (NiCr). 99.6% alumina is also useful for capacitor fabrication because of its dielectric constant ( 9.9).
**96% alumina** has a higher filler content and consequently is somewhat easier to cut with a diamond saw. It is normally used for thick film fired circuits because the thick film pastes do not adhere as well to purer alumina. The surface is frequently lapped for circuit applications, but can be polished if required.
**92% alumina** has even more filler and is useful for packaging applications where multiple layers of ceramic and conductive layers are built up. While softer than the previous types of alumina, it can present challenges for accurate dicing because of the thicker layers and pattern distortion during fi

### ALUMINUM NITRIDE (ALN)

- Useful for high power circuits which require a lot of heat dissipation because it has high thermal conductivity and a low thermal expansion coefficient.
- **Thermal conductivity**: 80-100 W/m-K
- Can be polished with a finish similar to alumina and is generally easier to dice than 99.6% alumina. Alkaline solutions such as many detergents can form a surface oxide which may be detrimental to the performance or appearance of the circuit. Our engineers will discuss the proper processing techniques to assure that your circuits have the optimum perform

### BERYLLIUM OXIDE (BEO)

- Useful for circuits which must dissipation large amounts of heat.
- **Thermal Conductivity**: 248 W/m-K (higher than many ceramics including alumina and aluminum nitride)
- **Dielectric Constant**: 6.5 (low for a ceramic circuit substrate)
- The primary limitation is the potentially hazardous dust. Our engineers are prepared to discuss tradeoffs in the properties of various ceramics in the design of circuits requiring heat dissipation&

### CERAMIC

- Include many hard metal oxides and nitrides.
- The term is derived from the Greek keramos which means “pottery” which comes from an older Sanskrit root meaning “to burn”. Certain materials like silicon carbide (SiC) stretch the definition somewhat but can be considered in the ceramic family.
- Have a wide range of mechanical, electrical, and optical properties.
- Ceramic substrates are typically wax mounted on glass and cut with a diamond blade using a directed flow of water.&

## COPPER (CU)

- Ductile metal that has very high electrical and thermal conductivity.
- Typically machined with metal cutting tools instead of diamond saws. However, many electronic applications require precise cuts or unique coatings on copper plates or wires.
- We can plate copper with nickel/gold (Ni/Au) for example and then diamond machine it to burr free shapes for submounts and other applications.
- Copper submounts have a burr after dicing due to smearing of the soft copper and gold. Our exclusive process will remove the burrs, resulting in a submount that will lie flat in the package.&

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## GALLIUM ARSENIDE (GAAS)

- Useful to the electronics industry for its semiconductor properties.
- Considered a rival to silicon in this industry because it requires less electric power and may process data faster.
- Gallium arsenide wafers are typically diced on tape or wax mounted on glass depending on the final requirements for chipping and cleaning. Tape cutting simplifies handling but can cause more edge chipping than wax mounting on glass. Wax mounting on glass will allow more precise thru cuts and grooves, but requires more handling during demounting and cleaning.&

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## GARNET

- Garnets are metal silicates such as calcium aluminum silicate ($Ca_3Al_2(SiO_4)_3$). There are a variety of types with different compositions that exist in various colors.
- Better known as gemstones than substrates, but they do have applications in electronics and optics. &

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## $LINBO_3$

- Useful in photonics for its nonlinear optical properties.
- A synthetic crystal that is hard, transparent, and dense.
- Switches, multiplexers and waveguides made on lithium niobate substrates may require the intricate machining and singulation that Kadco 's capabilities include.&

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## PIEZOCERAMIC & PIEZOELECTRIC MATERIALS (PZT)

- Piezoelectric materials produce a voltage proportional to the mechanical pressure applied to them. Basically, they change electrical energy to mechanical energy and vice-versa. For electronic applications, lead zirconate titanates (PZT) or barium titanates ($BaTiO_3$) are frequently used in substrate form.
- Tend to be very fragile and friable compared to other electronic substrates. Kadco has experience metalizing, dicing and machining these materials to minimize chipping and maintain proper adhesion of metal on the surfaces.&

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## PLASTIC

- Plastics are not normally thought of as substrates for dicing because of their softness. However, laminates of ceramics or metals and Kapton for example may require diamond machining.
- Two critical issues that require expertise in processing are mounting the substrate and avoidance of stringers. Since many plastics don't adhere well to dicing tape or wax, the engineer must plan for appropriate fixturing. Plastic stringers can form if the dicing parameters are not carefully investigated. &

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## PYREX

- Also known as borosilicate glass
- Occasionally used as a substrate because of its low coefficient of thermal expansion.
- Not likely to shatter and will not break easily.
- Dicing parameters must be carefully determined to minimize chipping and fracturing. &

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## QUARTZ ($SIO_2$)

- Useful in electronics for its piezoelectric and dielectric properties and has many and varied photonic applications.
- As a substrate it is very hard and comes in a number of different crystal orientations. This can present problems for diamond dicing and machining if the cutting parameters aren't carefully selected initially and monitored during the course of cutting.
- Kadco has processed quartz substrates larger than 6" square and thicker than 0.150".&

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## SAPPHIRE ($AL_2O_3$)

- Single crystal alumina, as opposed to alumina substrates which are multi crystalline. Sapphire comes from the Persian safir which means "beloved of Saturn".
- Has many desirable optoelectronic applications
- May be difficult to machine due to its hardness.&

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## SILICON (SI)

- Famous for its semiconductor properties.
- Primarily comes in the form of wafers for electronic applications.
- Wafers can be tape mounted for ease of handling the die after cutting or can be wax mounted on glass to minimize chipping. We can apply a resist coating before dicing to prevent silicon dust from adhering to critical surfaces. This can be easily removed with acetone or photoresist developer.
- Many different geometries can be etched into silicon. Deep trenches with straight sidewalls usually must be done by diamond machining.
- Our engineers have experience diamond machining silicon as much as 0.5" (13 mm) thick. &

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## TUNGSTEN (W)

- Hard metal that has electronic applications as a submount for soldering chips into packages.
- Kadco can plate metals such as nickel and gold (Ni/Au) on tungsten shapes and then diamond machine submounts which are burr free and ready for soldering.
- We have many different sizes in stock.&

## YTTRIUM ALUMINUM GARNET (YAG)

- Well known for its optical applications.
- Diamond machining may be required for isolation cuts on the surface or other patterning.
- Kadco's engineers have experience with controlled depth grooves to give you high yields on your product.&