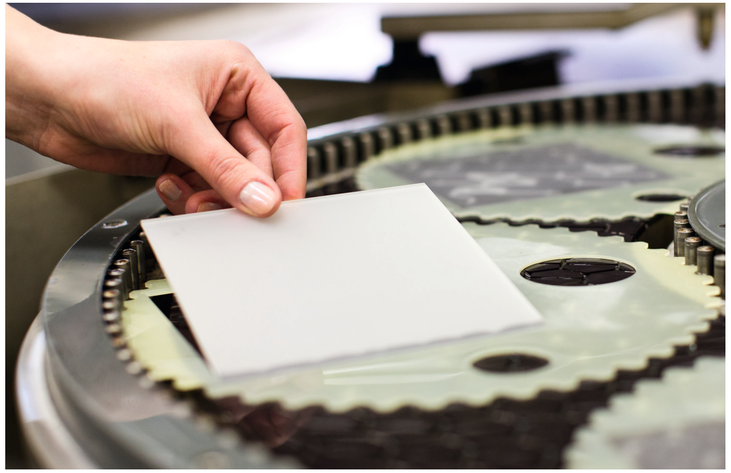
process results
dopa double-side grinding



After wire sawing the industry usually goes to a double sided lapping process using Boron Carbide on cast iron wheels. This process takes away the sawing marks and improves the wafer's flatness. The downside is that lapping is with removal rates of typically 1 µm/min very slow, consumes a lot of expensive lapping powder and produces high SSD. It is further a very dirty process that contaminates surrounding areas and makes an intensive cleaning of the wafers necessary.

The **dopa process** uses fixed abrasive grinding wheels that have a much higher removal rate than the above described lapping. Furthermore are those diamond wheels using no slurry that needs to be replaced every few hours. The **dopa process** runs with 97% water-based coolant in recycling mode. This combination cuts down your cost by simultaneously increasing your productivity. dopa grinding can completely replace loose abrasive lapping:

- **dopa grinding** significantly reduces cost per part compared to loose abrasive lapping
- With **dopa grinding wheels** you have higher material removal rates (MRR) compared to lapping
- Excellent TTV, Flatness and Bow/Warp after grinding with dopa wheels
- The surface roughness is lower compared to lapping and the parts have very low subsurface damage
- dopa grinding throughput is much higher than in lapping
- Due to the water based process the clean wafers require no special cleaning

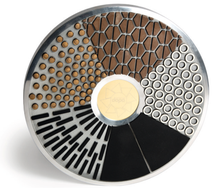
Performance of dopa grinding compared to standard lapping process

	Lapping process	dopa grinding
Cleaning effort	High −	Low +
TTV [µm]	≤ 6 −	1 - 2 +
Roughness Ra [µm]	0.8 - 1.2 o	0.3 - 1.2* o
MRR [µm/min]	1.2 −	≥ 3* +
Capacity Increase	na o	3x +
Cost Reduction	na o	up to 70 % +

** depending on wheel grit size*

dopa solutions for Sapphire

dopa offers a variety of products and services to process sapphire parts



Fixed abrasive grinding wheels Diamond wheels to replace loose abrasive (B4C or SiC) lapping / Fixed abrasive fine grinding wheels to replace or cut down DMP

Coolants, Diamond slurries and **CMP slurries** / We produce and develop grinding and polishing fluids in different grit sizes and formulations

DMP wheels / dopa DMP wheels for fine diamond polishing

Carriers / We manufacture lapping and polishing carriers customized to your part and wafer sizes and all common equipment types

Dressing tools for dressing and conditioning of your dopa grinding and polishing wheels **Other consumables** for grinding and polishing

Process development and **customized process solutions** for sapphire and many other materials

dopa DIAMOND TOOLS

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Your revolution
in Sapphire processing

dopa Developing and manufacturing high precision grinding and polishing tools

the dopa **sapphire process**

dopa – for over 25 years we are your competent and internationally established partner for the development and production of diamond tools and the design of turnkey production processes. We have specialized on the processing of hard and brittle materials like glass, specialty ceramics and crystalline materials. Over the past 10 years our special focus was the development of new technologies to process Sapphire.
We have analyzed the established lapping and polishing processes for Sapphire wafers. For all process steps we identified the key factors that cause high cost, long cycle times and unstable process quality.

As a result we have introduced several forward looking solutions:

- **dopa fixed abrasive** technology replaces lapping with loose abrasive
- **dopa fixed abrasive** technology cuts down / replaces DMP
- **dopa fixed abrasive** works with single-side and double-side equipment

You get the maximum efficiency increase when you combine the **dopa fixed abrasive wheels** with double side processing all way through. Then you can reduce the number of process steps, the total cycle time and the total costs per part significantly:

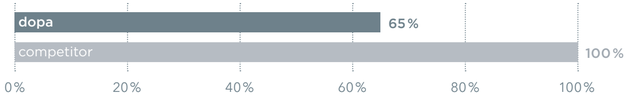
process **steps**

The **dopa technology** reduces the number of process steps up to 50% by using double side manufacturing all the way through grinding, DMP and CMP. It furthermore eliminates a lot of various handling & cleaning steps by simultaneously improving your quality.

cycle **time**

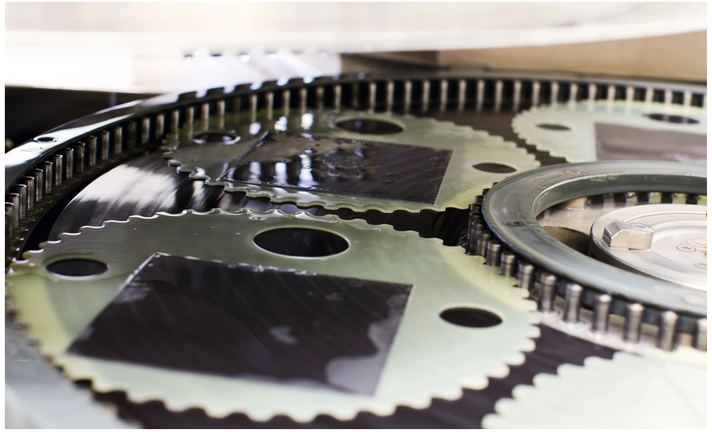
The **dopa process** is up to 40% faster than the established process. Instead of Lapping with loose abrasive we apply the clean and fast dopa grinding. Due to the low subsurface damage (SSD) of the dopa grinding we are able to reduce the necessary material removal in polishing. This saves time and money.

cost per **part**



The **dopa sapphire process** reduces the cost per part up to 35%. Key factors are the cost efficiency of the dopa grinding wheels combined with the fine and homogeneous surface finish they produce.

process results
dopa double-side fine grinding



Sapphire wafer lapping is commonly followed by a single sided diamond mechanical polishing step (DMP). The DMP is used to remove the rough lapped surface and prepares the wafer for final polish. Typically a removal of 25 to 35 µm per wafer side is necessary to eliminate the damage layer created in lapping. This takes between 30 to 50 min each side of the wafer depending on used grit, wafer size and sapphire orientation (waxing and unwaxing processes as well as intermediate cleanings are not included). The biggest downside of the DMP-process is the high consumable cost for diamond slurry.

dopa has developed fixed abrasive fine grinding wheels that remove material much faster than DMP and have simultaneously a very small damage layer. On A-, R- and M- plane wafers dopa is able to achieve outstanding fine and homogeneous surfaces. Already after removing 3 µm per side in CMP the wafers have a totally transparent surface with a roughness of below 0.4 nm.

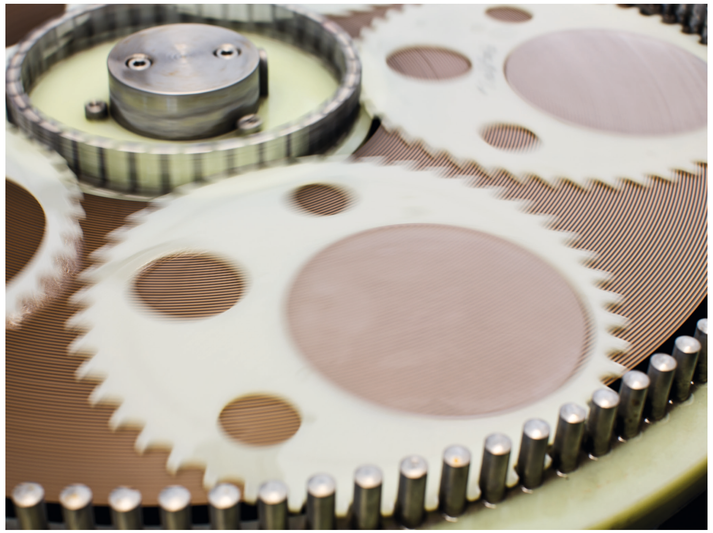
The double sided fine grinding has the following advantages compared to DMP:

- Much lower cost per part
- Slurry free process – fine grinding runs with 97% water plus 3% **dopa coolant** in recycling
- Fine grinding plates stay flat. There is no such temperature based flatness change as in DMP
- secures good TTV and wafer flatness
- Flatness correction of grinding wheels takes only a few minutes
- No waxing and unwaxing processes needed
- Cleaning from wafers after fine grinding much easier, faster and cheaper than after DMP
- Wafers of different batches can be ground into the identical thickness – less sorting
- Much higher cut rate than DMP

Performance of dopa fine grinding compared to standard copper DMP

	Copper DMP	dopa fine grinding
Cleaning effort	High –	Low +
TTV [µm]	≤ 5 –	1 - 2 +
MRR [µm/min]	0.7 –	≥ 1.2 +
Capacity Increase	na o	2x +
Cost Reduction	na o	up to 70% +

process results
dopa double-side DMP



dopa has developed DMP solutions for those cases where customers want to further cut down their CMP time or look for superior wafer finishes in an overall shorter process time. **dopa DMP plates** consist of pure synthetically produced ingredients at a fixed in house production process. This secures a homogenous and repeatable hardness and bonding over the whole plate. The advantage of **dopa DMP wheels** compared to copper or resin copper wheels are:

- **dopa plates** create a finer surface finish and less subsurface damage using the same grit size diamond slurry – this shortens your CMP time
- After **dopa DMP** you usually have to remove only 2 µm to create an EPI-ready surface
- Polishing on dopa plates keeps the temperature during the DMP process very low – good TTV and wafer flatness
- Shape correction or surfacing is much easier and faster on dopa plates

dopa plates consume smaller volumes of diamond slurry to achieve good removal rates. This reduces your slurry cost. Using dopa DMP plates cuts down your overall process time and secures a short CMP cycle. It furthermore enables you producing parts with better flatness specifications.

Performance of dopa DMP compared to standard copper DMP

	Copper DMP	dopa DMP
Cleaning effort	Standard o	Standard o
TTV [µm]	≤ 5 –	≤ 2 +
Roughness Ra [µm]	0.025 +	0.015 +
MRR [µm/min]	0.7 –	up to 1.0 +
Capacity Increase	na o	up to 10% +
Cost Reduction	na o	up to 30% +