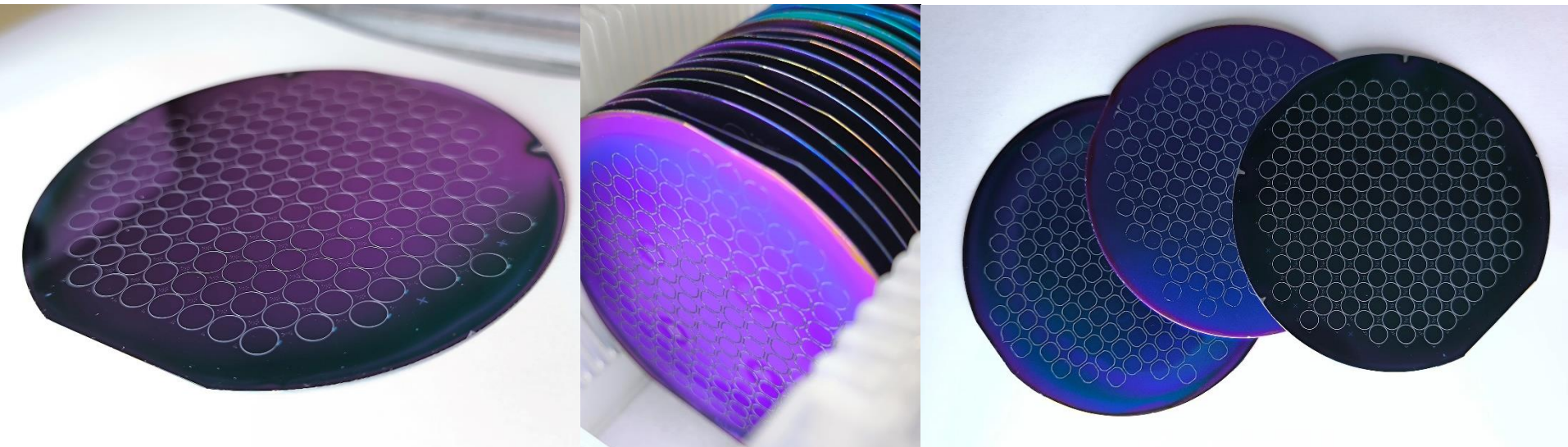


Silicon wafers with p-type through wafer channels

New type of silicon wafers

2024 September



Overview



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The company launched production of a new silicon wafer with customized p-type through wafer channels.

A new type of silicon wafers (4 and 6 inches diameter) with through p-type channels, orientation (100) and (111)

We now searching clients ready to execute R&D on these wafers.

Possible areas of application:

- contacts in photodetectors, ionizing radiation detectors, pressure sensors, temperature sensors
- power semiconductor devices with an insulated chip edge
- power semiconductor devices with an integrated control circuit
- 3D integration, power semiconductor devices
- 3D TSV (through-silicon via)
- MEMS devices

We are open to cooperation in manufacturing wafers for your applications!

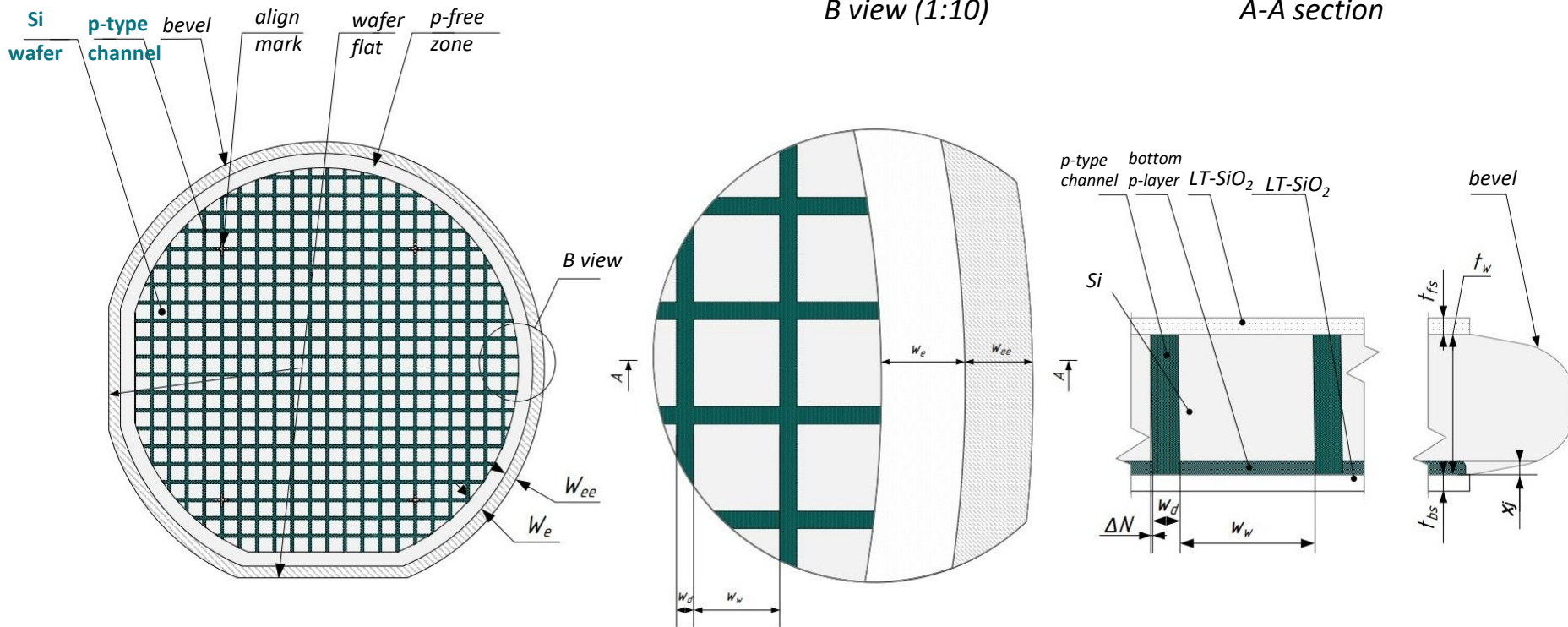
P-type through wafer channels



Layout pattern “grid”

Wafers with p-type through channels are manufactured according to the customer’s layout.
Wafers 4/6 inch, orientation (100) or (111).

The layout with **entire grid of p-type channels** and a bottom p+ layer (optional):

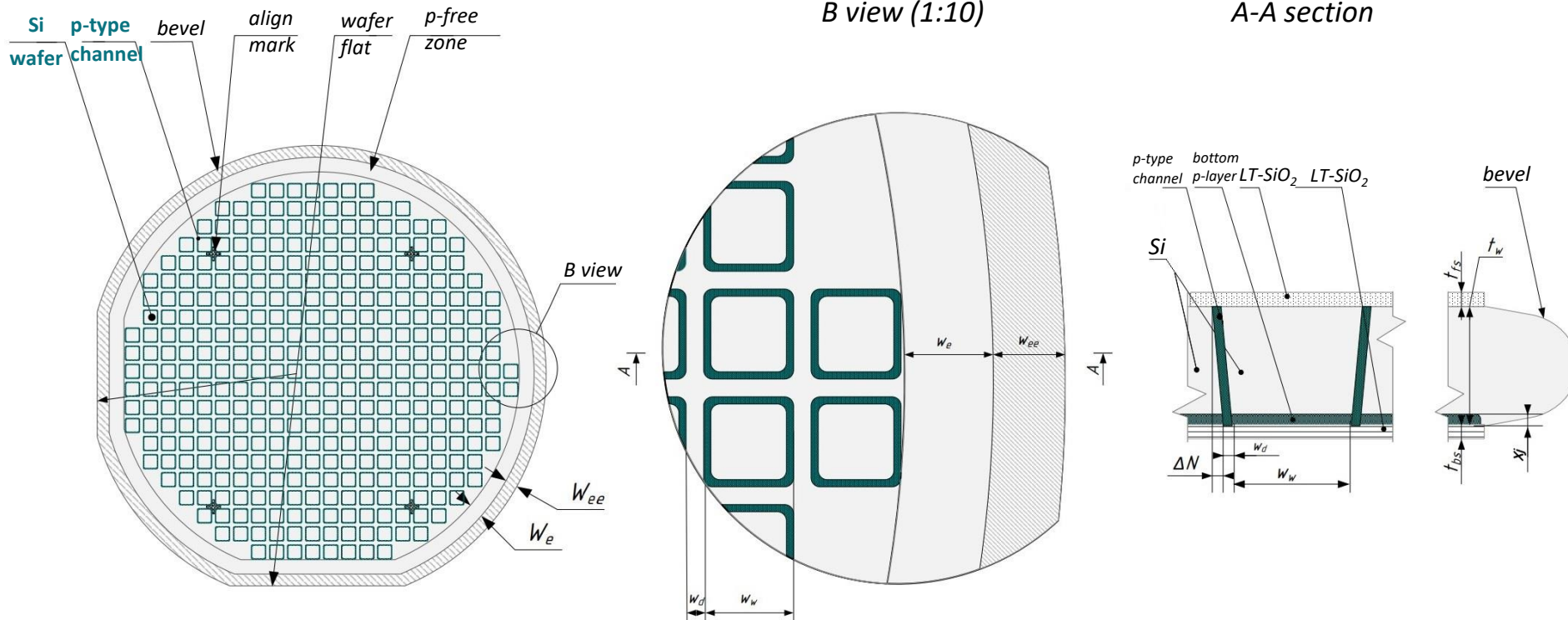


P-type through wafer channels

Layout pattern “annular”



The layout with **annular p-type through channels**, an insulating n-well and a p+ underlayer (optional):

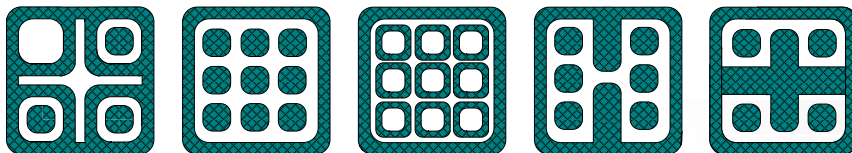
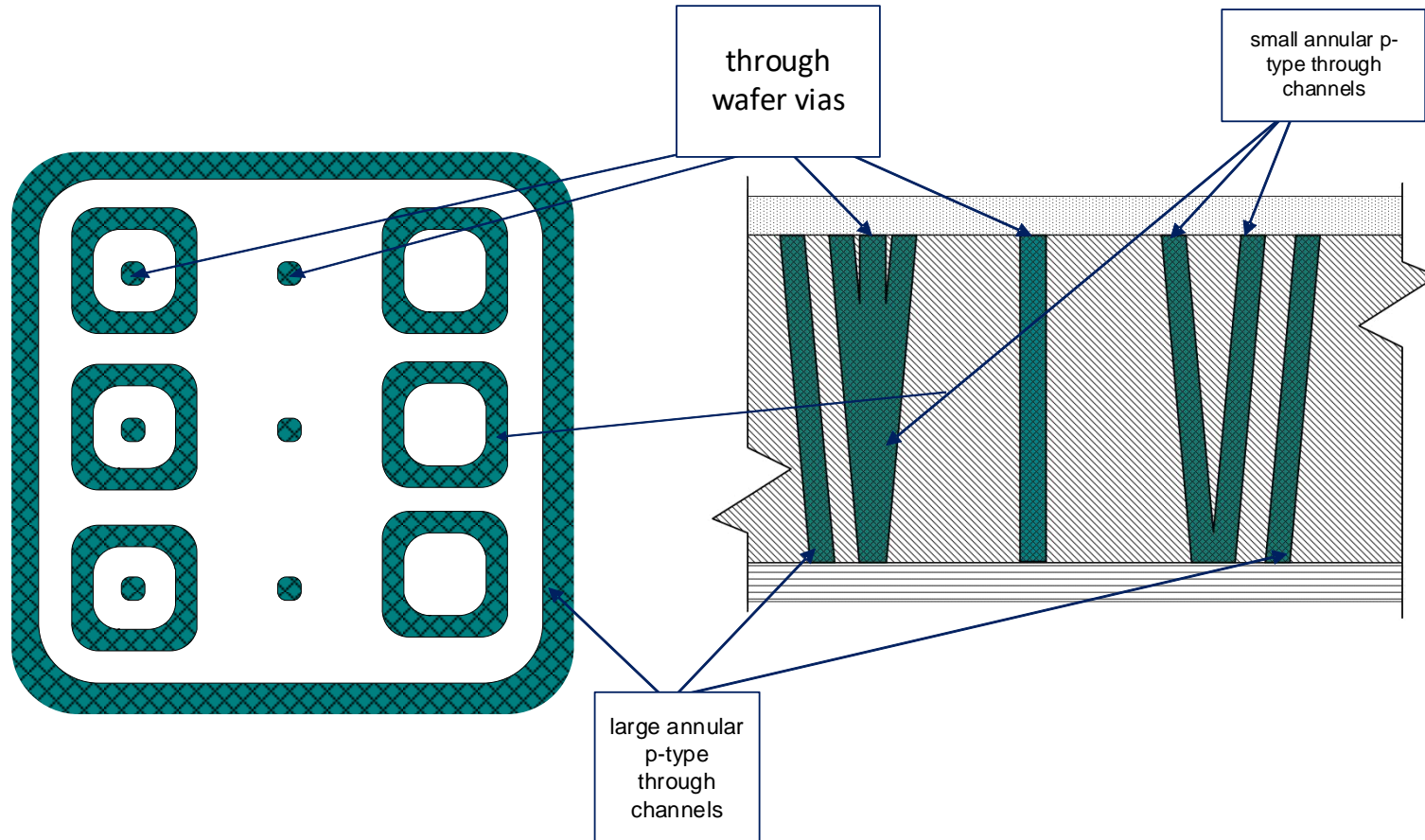


P-type through wafer channels

Layout pattern “combined”



Various combinations of **annular, grid and point p-type through channels**:

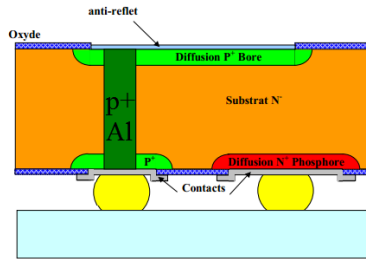


P-type through wafer channels

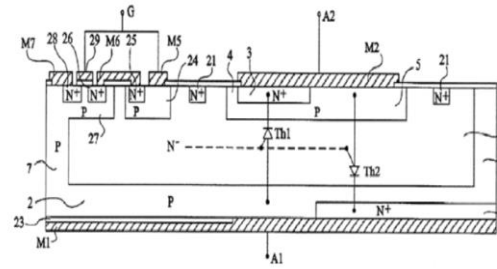
Global expertise



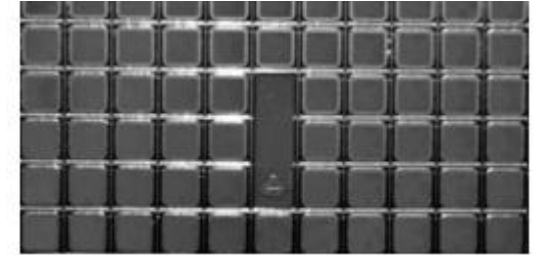
Areas of application of structures with p-type elements produced with TGZM:



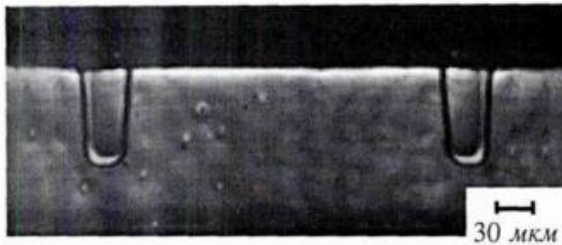
Transferring contacts to the back side of the dice



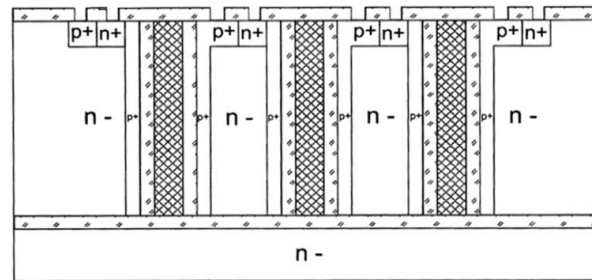
Symmetrical Thyristor/IGBT (Bidirectional Switch)



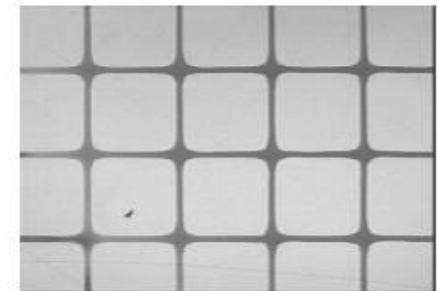
Diode wafer with anode on the bottom side (top view SEM)



Power JFET with p-type gates produced with TGZM (SEM image)



High-voltage photocell



Grid of p-type through channels (top view SEM)

P-type silicon needles matrix

Application

Various combinations of insulated **conductive needles**



solid p-type needle

medicine

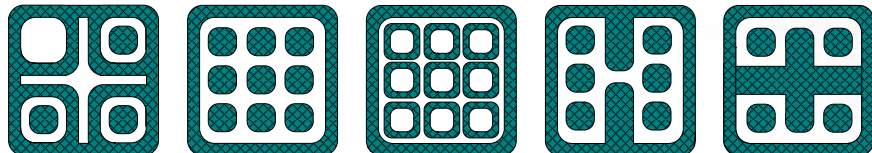
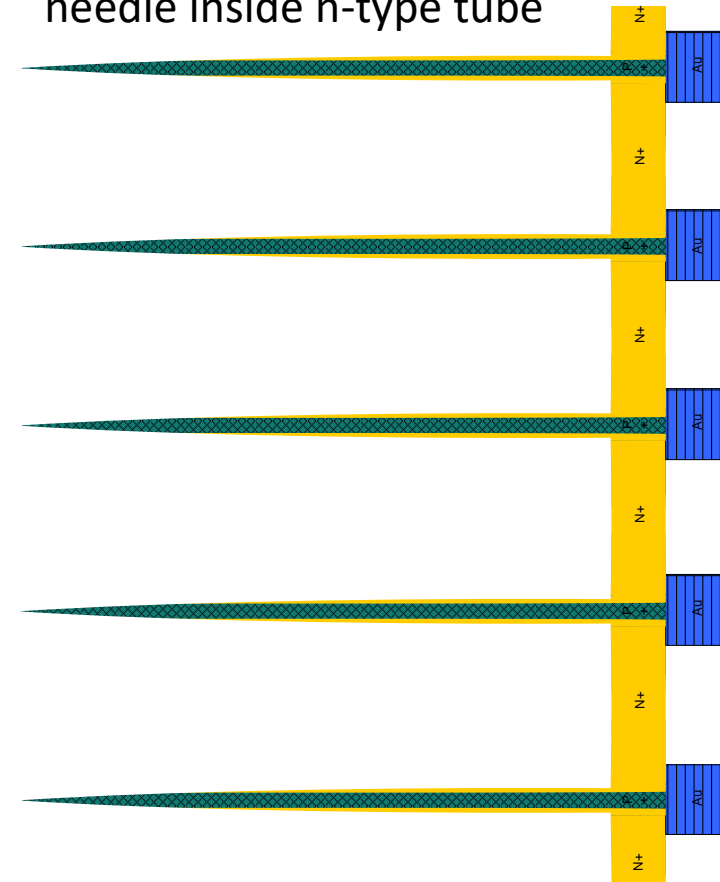
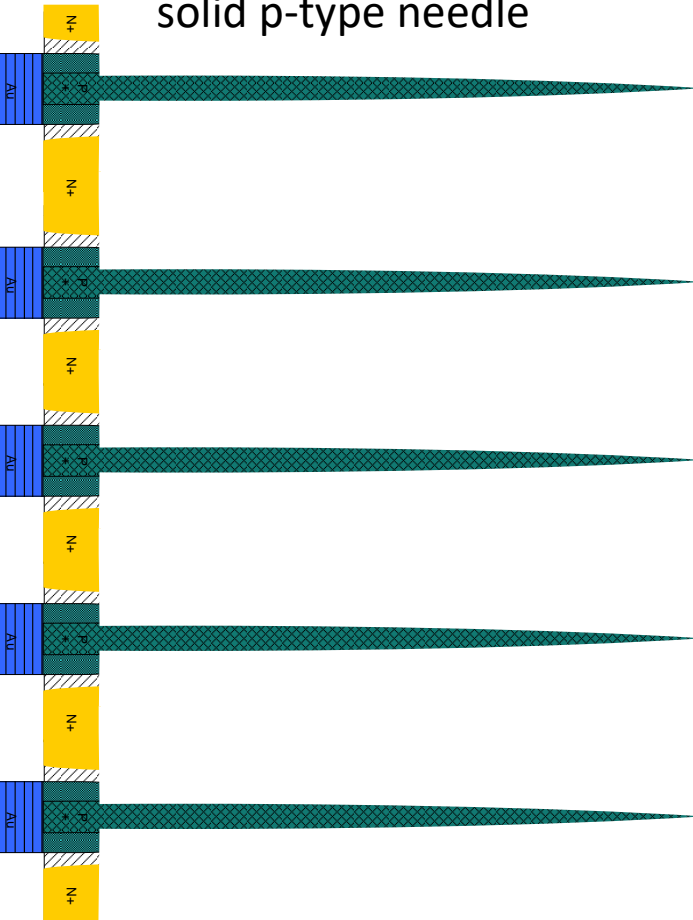
biology

testing

sensors

contacting

p-type insulated coaxial needle inside n-type tube



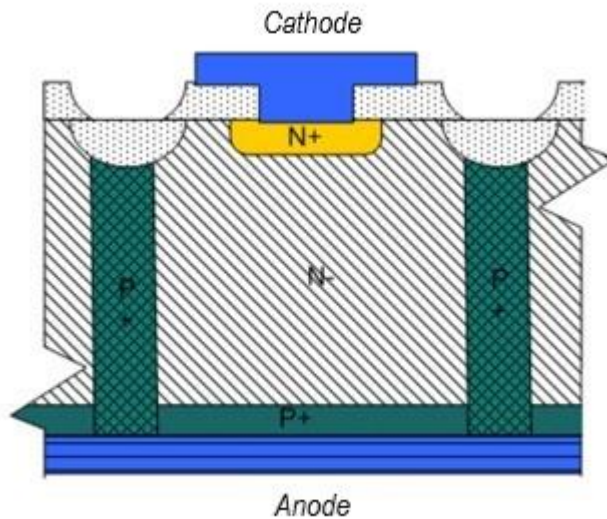
Reverse polarity diodes

Application



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Currently the company is developing the design of reverse polarity diodes with bottom anode terminal. Diodes with fully insulated n-drift region are manufactured using wafers with the p-type through channels. This device will simplify the technology of assembling power modules, increase the thermal and dynamic stability of parameters and the overall reliability of the product. The device has better technical and economic characteristics in comparison with the devices manufactured using conventional technology.



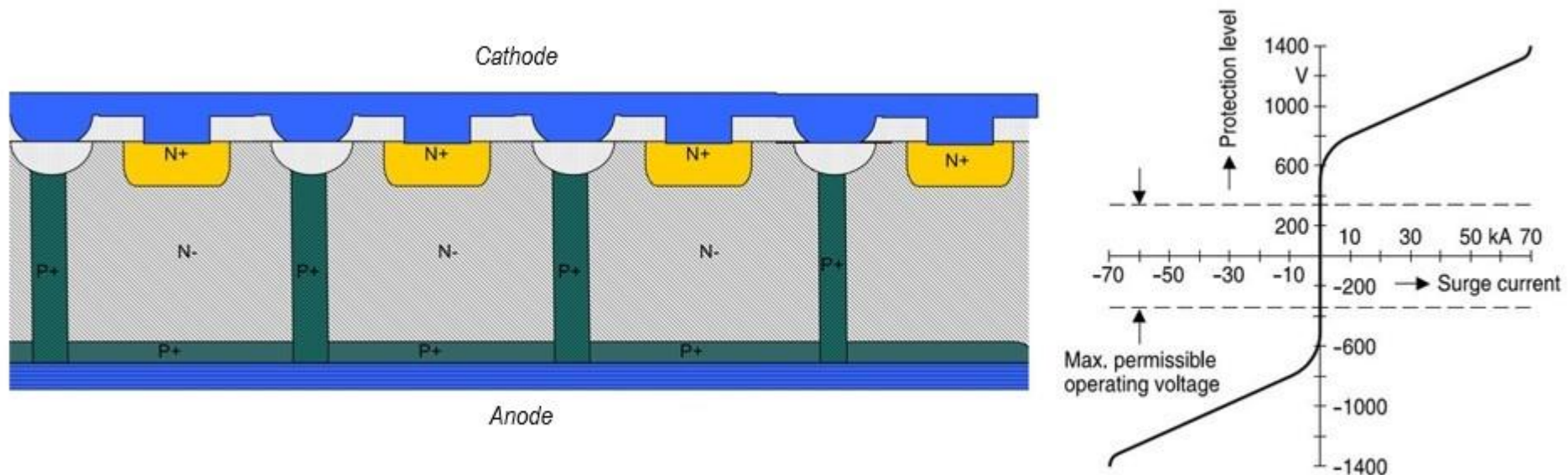
Due to through edge isolation the packaging of dice or bonding into a power module allows greater safety. The dice can be mounted with both the anode and cathode sides on the base, which simplifies the design and technology of creating bridge and half-bridge circuits. The dice can be assembled by pressing, bonding, ultrasonic welding both separately and in columns.

Powerful high-voltage transient voltage suppressors

Application

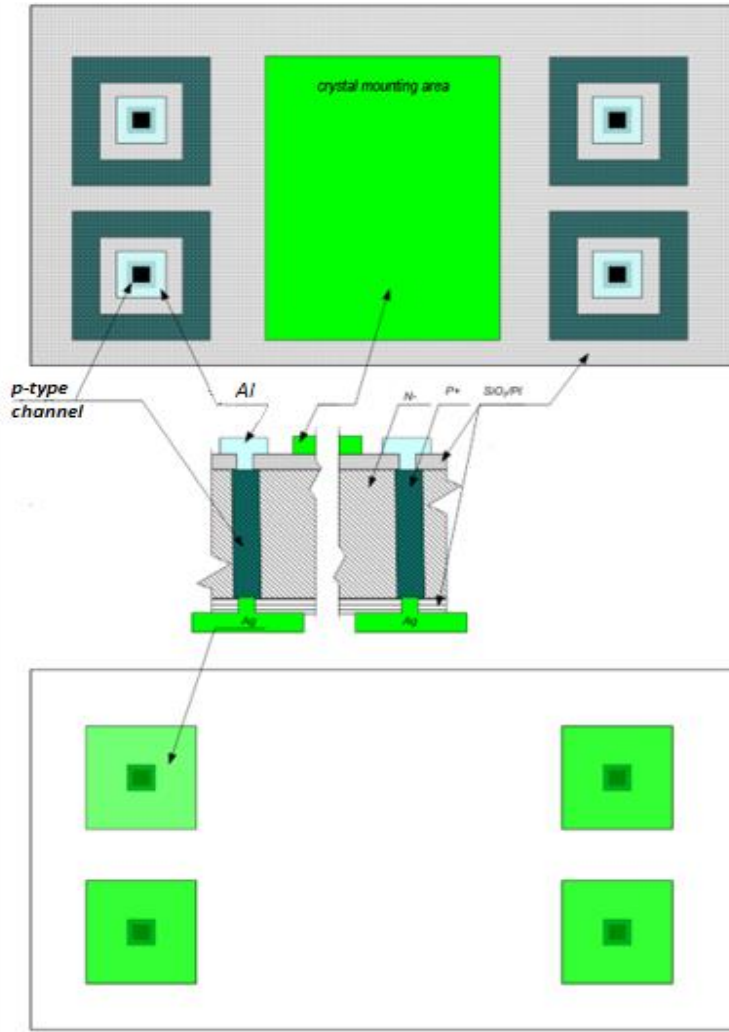


The technology with p-type through channels will significantly increase the durability of the p-n junction to current overloads that occur during spark/lightning breakdowns or switching overvoltage's. Due to volumetric integration it will be possible to produce voltage limiters with reduced differential resistance and increased resistance to pulse currents (compared to existing solutions based on planar p-n junctions). On the other hand it opens up the possibility of designing devices with similar parameters to varistors, but with significantly better performance, less leakage and higher reliability.



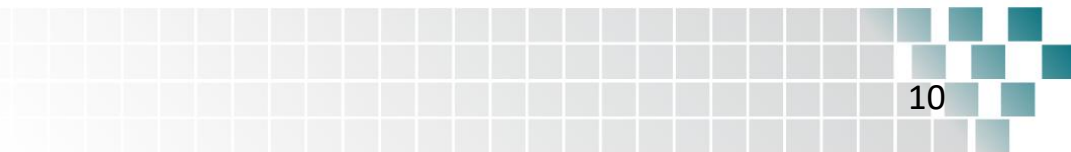
Point transient contacts («through wafer vias»)

Application



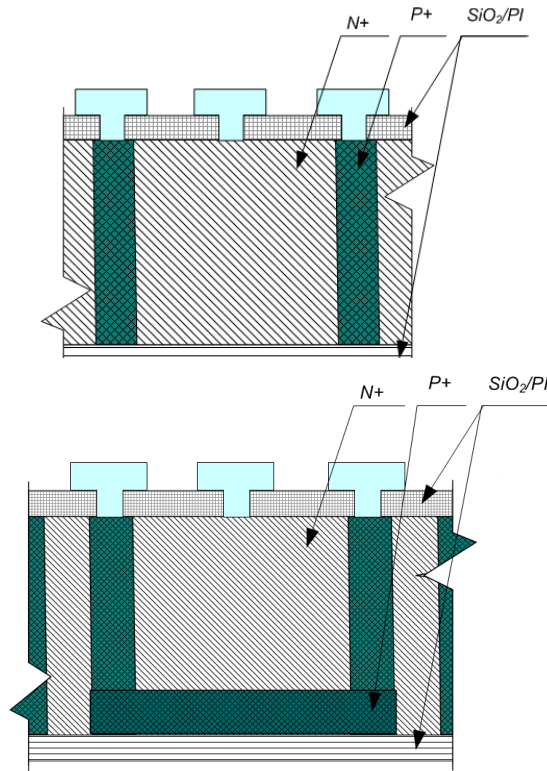
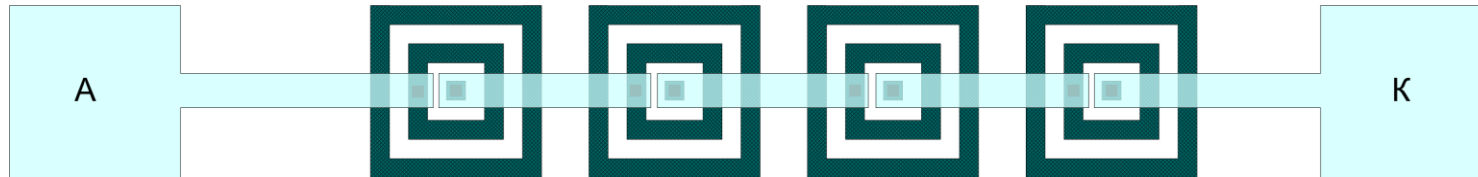
P-type through channels have a high doping level ($N_a > 10^{19}$). High doping level allows formation of through wafer conductive vias in insulating silicon circuit boards that have pads on the bottom side. This solution makes possible to produce miniature chip-sized carrier boards.

Silicon technology allows the formation of additional insulated pockets that contain additional semiconductor structures (protective diodes, resistors, temperature/photo sensors).



Chains of p-n junctions

Application



There is a possibility to form chains of series of insulated p-n junctions to achieve high-voltage reverse characteristics of diodes, or high-level thermally sensitive forward-biased p-n junctions.

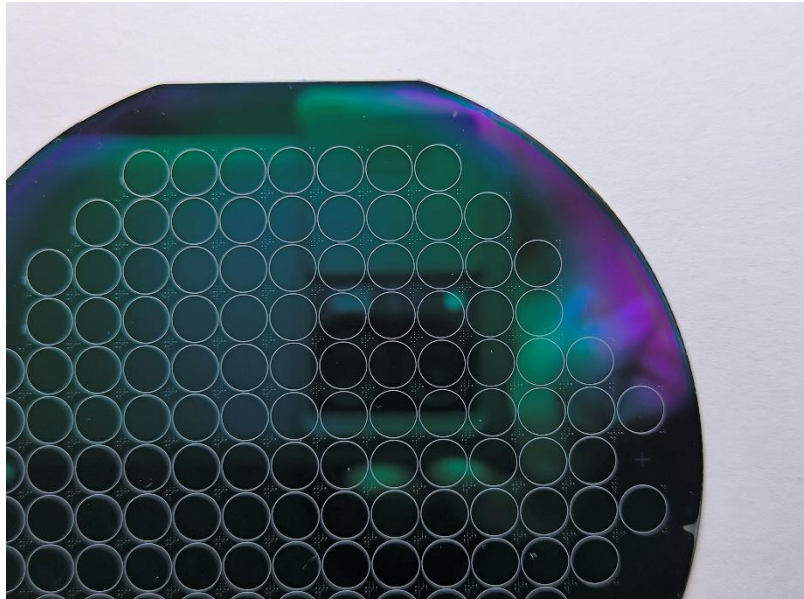
An individual cell may have a complete insulating environment with a p-n junction.

R&D Results Achieved

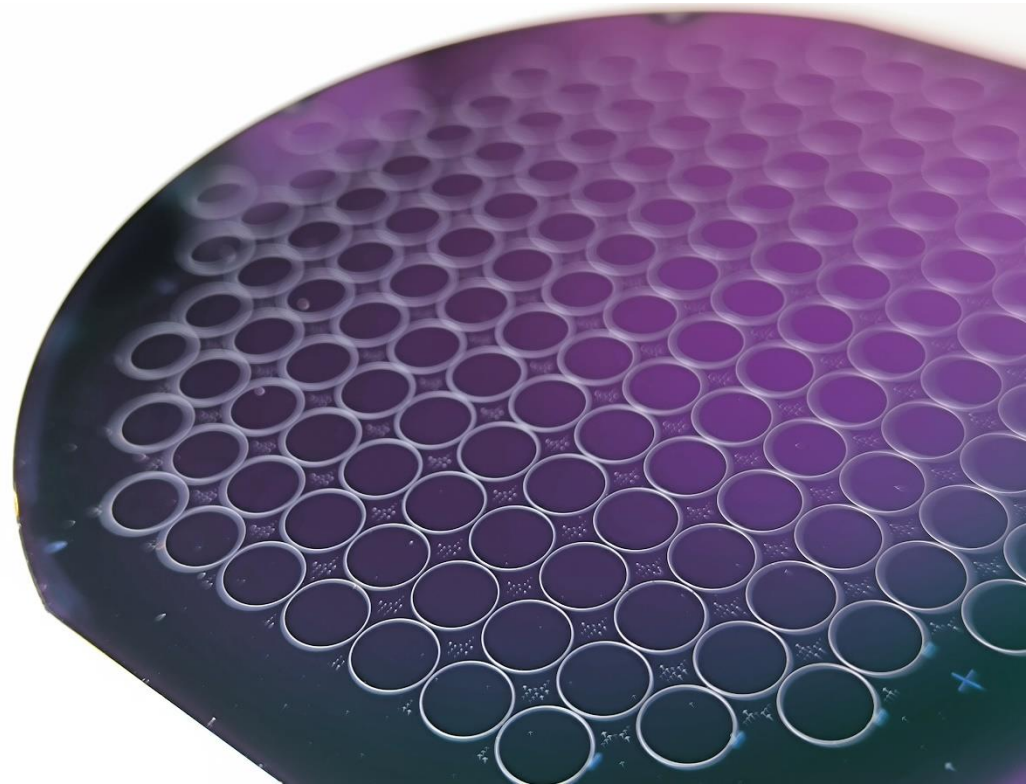
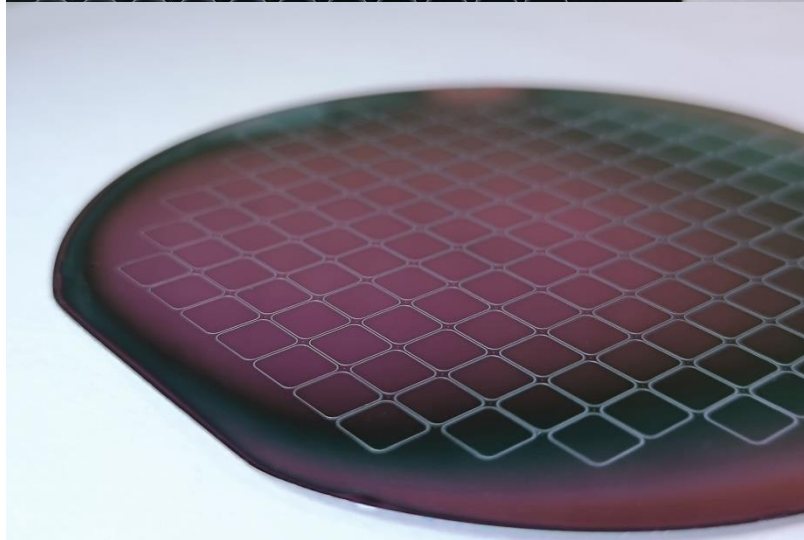
After the process



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4 inch n-type wafer right after the process of **patterning layout image off p-type trough channels**



R&D Results Achieved

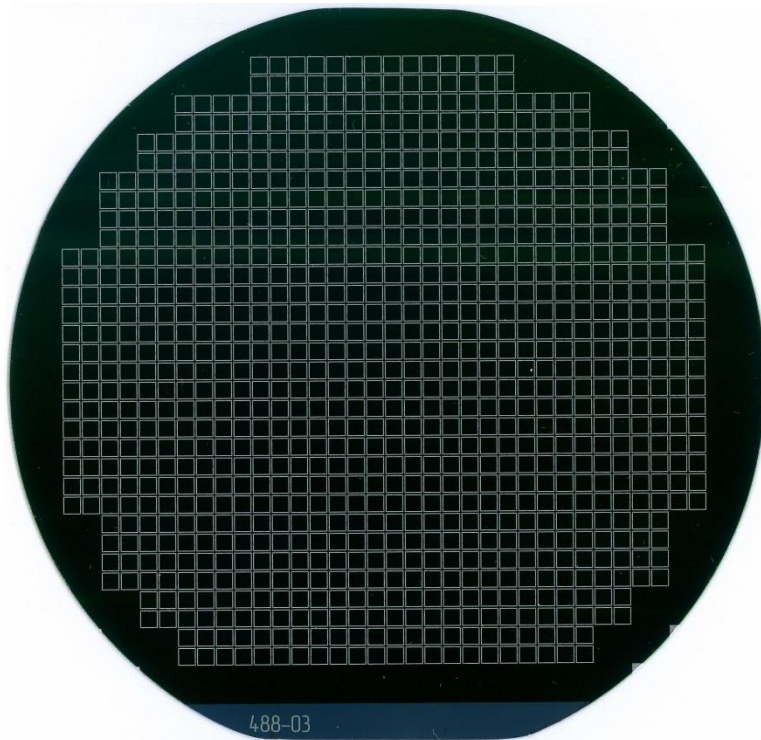
Before the process



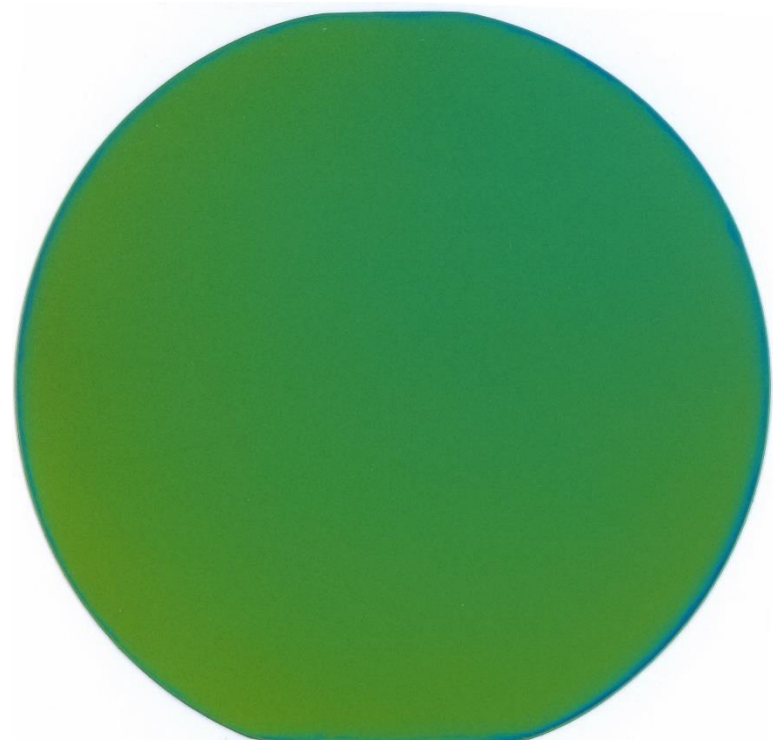
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4 inch n-type wafer with 100 orientation before the process of forming p-type through channels

front side of the wafer

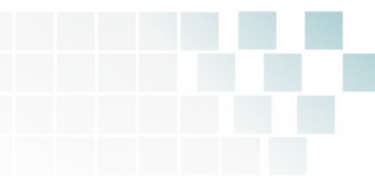


back side of the wafer



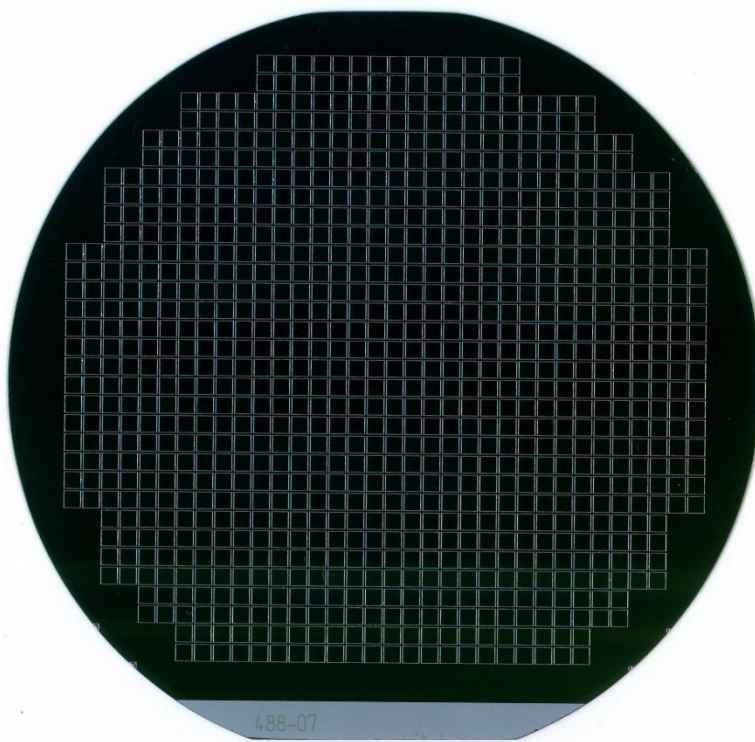
R&D Results Achieved

After the process

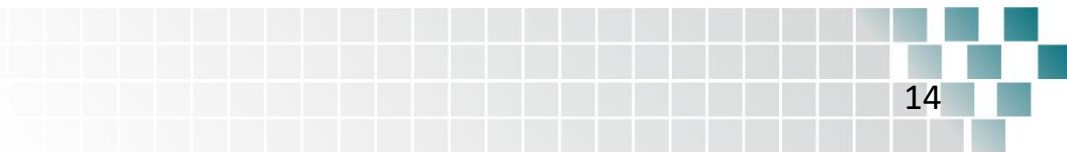
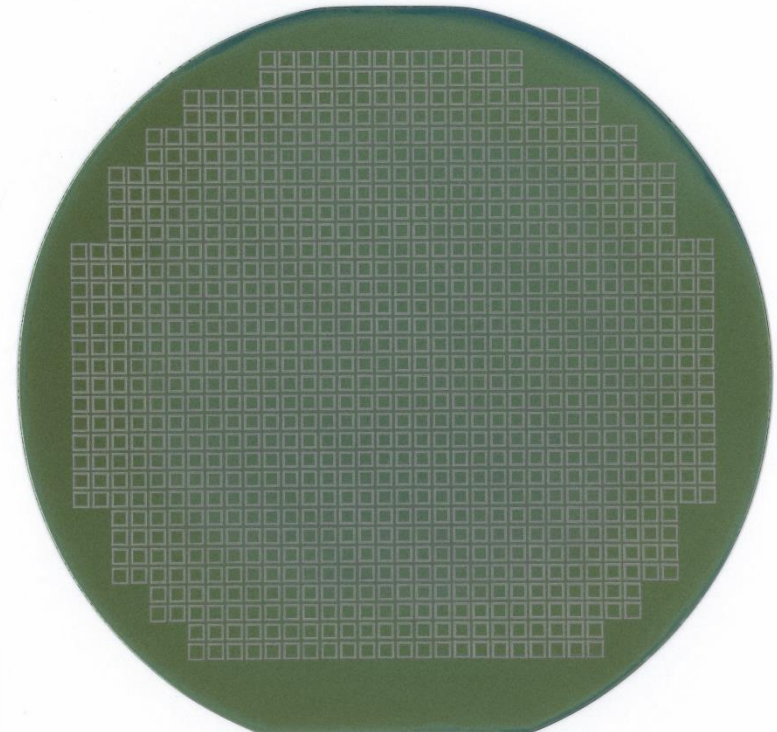


4 inch n-type wafer with 100 orientation right after the process of forming p-type through channels

front side of the wafer



back side of the wafer



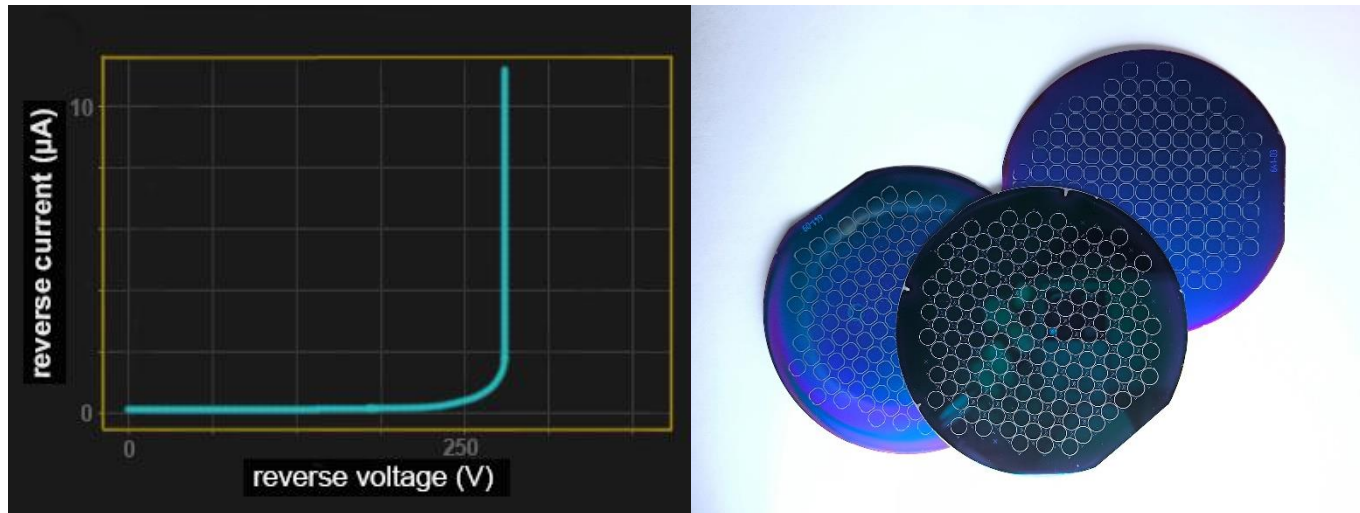
R&D Results Achieved



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Further is the current-voltage characteristic of a n-well insulated from the carrier wafer by p-type through channels. A special installation was assembled to carry out the thermomigration process.

The measured breakdown voltage was 270V, which corresponds to the breakdown voltage level of a flat p-n junction, while the resulting leakage $<10\mu\text{A}$ characterizes the high perfection of the channel.



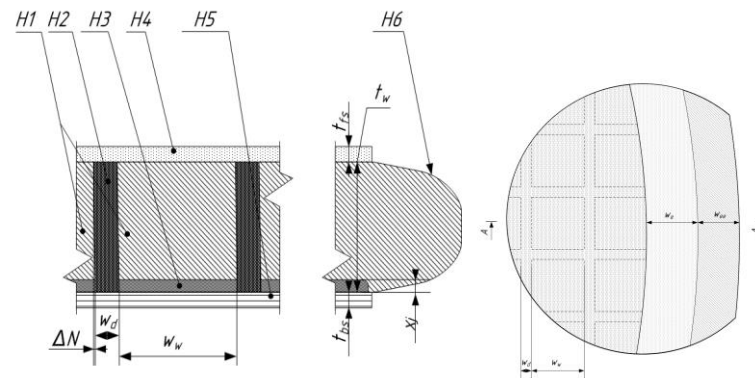
The results obtained allow to start testing wafers with p-type through channels in the production technology of various semiconductor diodes.

Specifications



Nowadays our company is developing standard specifications for the following types of wafers with structures based on p-type through channels, manufactured according to the customer's layout:

1. Silicon wafers with "p-type through annular channels";
2. Silicon wafers with "p-type through point channels";
3. Silicon wafers with a "combined p-type through channels layout"



Designation	Name of the element	Material	Controlled parameter	Allowable value
H1 (pic.)	Carrier wafer	Si	Resistivity ρ , tbd Density of microdefects Density of dislocations Width of well W_w Range of width of well (ΔW_w) (up/down) Thickness of silicon, t_w	1-100 $\Omega \cdot \text{cm}$ No more $2 \cdot 10^5$ No more $5 \cdot 10^2$ At least 100 μm No more 10% W_w $450 \pm 50 \mu\text{m}$
H2 (pic.)	P-type through channel	Si doped p-type	Resistivity ρ , tbd Density of microdefects Density of dislocations Width of end-to-end element, on the wafer W_d , tbd Range of width of end-to-end element on the wafer (ΔW_d) Deflection of end-to-end element from the normal to the surface ΔN tbd	Less than 0,02 $\Omega \cdot \text{cm}$ No more $5 \cdot 10^6$ No more $5 \cdot 10^3$ At least 20 μm No more 10 μm No more 10 μm
H3 (pic.)	Solid p-underlayer (optional)	Si doped B	Sheet resistance, R , tbd Depth, X_j , tbd	5-1000 Ω/\square 1-15 μm
H4 (pic.)	Upper protective layer (optional)	LT-SiO ₂ / LT-SiON/ LT-SiO ₂ +Si ₃ N ₄	Thickness of the protective layer., t_{fs} tbd	0,5-2 μm
H5 (pic.)	Bottom protective layer (optional)	LT-SiO ₂ / LT-SiON/ LT-SiO ₂ +Si ₃ N ₄	Width, tbd	0,5-2 μm
H6 (pic.)	Bevel	Si	Width of bevel, W_{ee} tbd	0,1 - 0,25 μm

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