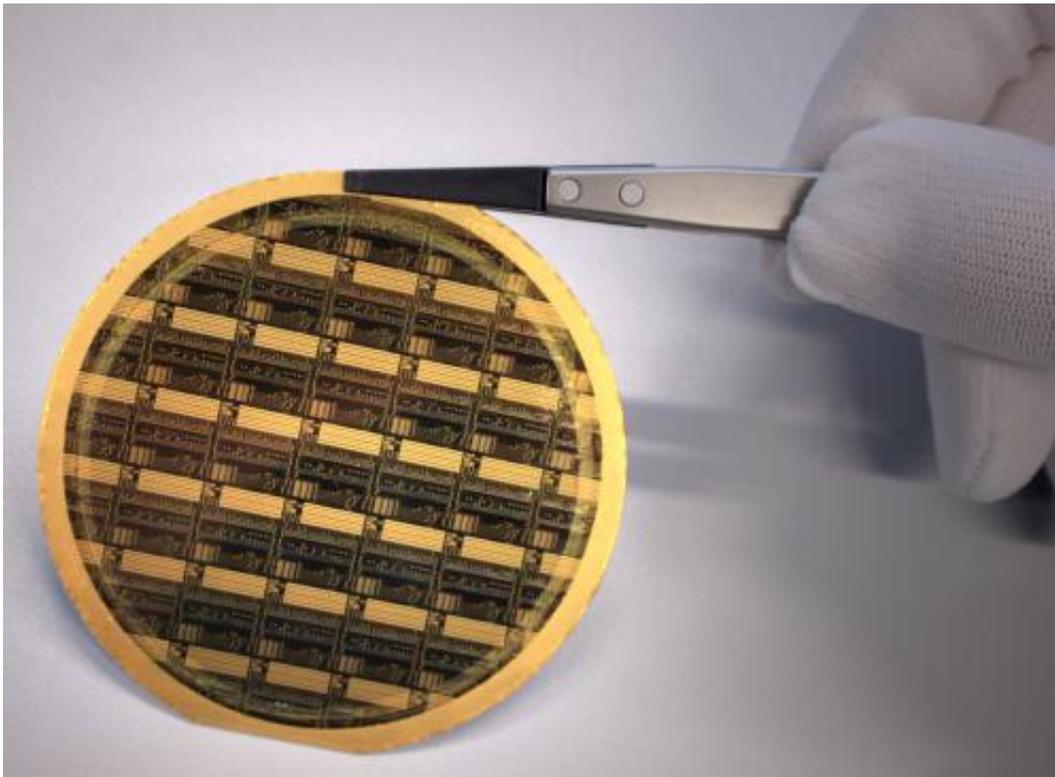


'Sandwich chips' combining the best of two technologies

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Wafer with "Sandwich Chips". Credit: BH/Immerz

Two Leibniz institutes in Germany broke new technological ground and successfully combined their – up to now separate – technology worlds. Due to their high performance the novel chips developed within the HiTeK project shall open up new applications.

Wolfgang Heinrich and Bernd Tillack are convinced of holding the key to faster and more powerful terahertz chips. The two scientists and their teams come from the Berlin-based Ferdinand-Braun-Institut (FBH) and from the IHP–Leibniz-Institut für innovative Mikroelektronik in Frankfurt/Oder – and thus from two different technology worlds. FBH is one of the leading institutes in developing III-V semiconductors, while IHP is specialized in silicon-based systems and circuits. Both Leibniz institutes joined forces within the HiTeK project to combine the advantages of silicon-based CMOS ([Complementary Metal Oxide Semiconductor](#)) circuits from the IHP with those of [indium-phosphide](#) circuits from the FBH. The partners now accomplished an important step within the project by successfully integrating both circuits on a [semiconductor wafer](#), with measurement results demonstrating their high performance. With the integration on one chip, new ambitious applications in the THz range are within reach such as high-resolution imaging systems for medical and security technology as well as ultra-broadband mobile communication applications.

For such applications high output powers along with faster computer processors are needed offering enhanced computer operation per second. In order to achieve this, circuits on the chips have to become smaller—the key reason which boosts miniaturization in [semiconductor industry](#). If the frequency range around 100 [gigahertz](#) and beyond is to be covered, however, the [breakdown voltage](#) in the CMOS switching circuits decreases significantly. Accordingly, the available output power of the chips declines, which implies that the capability to generate sufficiently strong signals to establish a radio link and to detect material defects becomes insufficient. To find a solution for this problem, IHP conducts research on bipolar CMOS based on silicon-germanium enhancing the breakdown voltages at high speed compared to pure CMOS. By combining a standard CMOS circuit with a second indium-phosphide circuit promises further improvement. Both circuits are realized "sandwich-like" on top of each other. Where the traditional

silicon-based CMOS technology reaches its limits, this novel material combination delivers the desired properties: high output powers at high frequencies. The sandwich chips allow to keep benefiting from the high level of production routine and integration of CMOS circuits – particularly regarding the fact that 95 % of all digital and analogue-digital circuits base on this technology.

"It was particularly challenging to make both technologies compatible at the interfaces", underlines Wolfgang Heinrich from the FBH. To achieve this, the whole development environment of both processes as, for example, the software for the circuit layout had to be merged in a first step. Subsequently, both layers had to be dimensioned so that they reach the essential good transmission properties for frequencies around 200 gigahertz. Precision work was also highly demanded to adjust the circuits precisely to each other with an accuracy of less than 10 micrometers. Heinrich is especially proud of the friction-less cooperation: "We managed to align both technology worlds so smoothly that the circuits deliver fully the specified high-frequency performance. This also demonstrates what added value can be created by bundling the competencies of two institutes like IHP and FBH".

The next steps are now to further stabilize the process and to optimize the circuits. A follow-up project has already been granted. This way, the potential of the hybrid chips shall be exploited fully to reach the borders of what is feasible – thus setting the stage for the novel sandwich [circuits](#) to be integrated in sophisticated applications soon.

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