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Analysis of the Huawei Mate 60 Pro Reveals SMIC 7nm (N+2)

On September 3, 2023, TechInsights received the Huawei Mate 60 Pro smartphone in its Ottawa, Canada lab. Huawei had released the device only days earlier in China. The TechInsights engineering and technical team immediately proceeded to tear down the phone. This high-end smartphone from Huawei was expected to feature a 5G application processor/SoC from HiSilicon, the Kirin 9000s.

The TechInsights team has not seen a flagship smartphone SoC (System-on-Chip) from HiSilicon in a couple of years. The previous version was analyzed in late 2020 and was determined to be manufactured by TSMC. Of note, this took place before the U.S. trade restrictions came into effect. The Kirin 9000s is particularly interesting as it implies that Huawei has advanced its semiconductor design tools - working with SMIC - to comply with U.S. sanctions.

For context, U.S. sanctions resulted in a massive drop-off of Kirin mobile chipset shipments. In 2019, Kirin shipments reached almost 250 million (including the Balong 5000, Kirin 990 and the 5nm Kirin 9000 with majority coming from the Kirin 990). In May 2020, TSMC announced it would not take any new orders from Huawei which resulted in an abrupt drop in Kirin chipset shipment units – 4.4M in 2022.

SMIC's technology advances, however, are on an accelerated trajectory and appear to have addressed yield-impacting issues in its 7nm technology. The China-based foundry has been able to scale last year's 7nm (N+1) to its next generation 7nm (N+2) with a more complicated process allowing them to increase density and provide the design options for the most advanced 7nm designs. This opens the door to a fully domestic advanced SoC design and manufacturing ecosystem.

To serve the advanced smartphone semiconductor market, the Kirin 9000s processor must include embedded memory. This required TechInsights to confirm if it's the full process version of the SMIC 7nm (known as N+2).

During the teardown of the Mate 60 Pro, the team found the application processor on the main PCB which was the HiSilicon processor. Interestingly, it has the following markings:

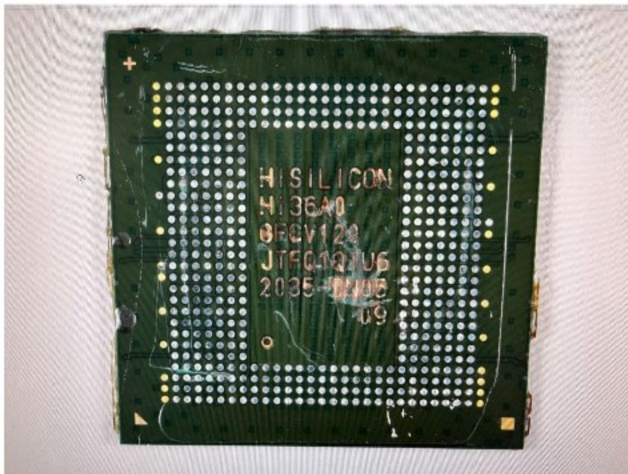

Figure 1: HiSilicon Kirin 9000s. TechInsights, 2023.

Note the markings "2035" indicate that it was packaged in week 35 of 2020. This initially does not look very promising to find the SMIC 7nm N+2 variation. However, the GFCV120 marking was new to TechInsights. Despite this, our team continued the analysis and removed the die from its package.

The Kirin 9000s die measured 107 mm^2, which is 2% larger than the Kirin 9000 (105 mm^2). From various identifying features on the die, the team concluded that the processor is manufactured by SMIC.

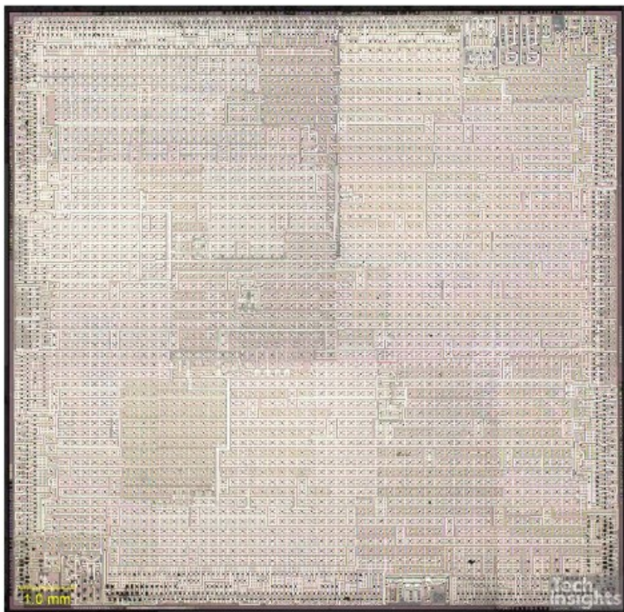

Figure 2: HiSilicon Kirin 9000s, top metal die photo. TechInsights, 2023.

At this stage, the TechInsights analysts were intrigued, and determined to confirm which SMIC process node was used in this Kirin 9000s processor. Initial lab results indicated that this die is certainly more advanced than SMIC's 14nm process node but presents larger critical dimensions (CDs) than what Techinsights has observed for 5nm process.

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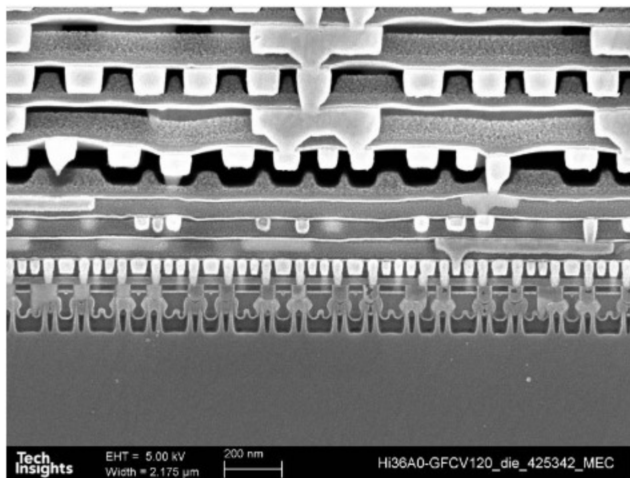

Figure 3: HiSilicon Kirin 9000s. SEM image showing SEM cross-sections across fins – showing fins and lower metal layers. TechInsights, 2023.

After additional measurements of CDs on the die, including logic gate pitch, fin pitch and lower back-end-of-line (BEOL) metallization pitches, the analyst team concluded the die has 7nm features.

At this point, the TechInsights team confirmed, with high confidence, that SMIC 7nm N+2 was uncovered.

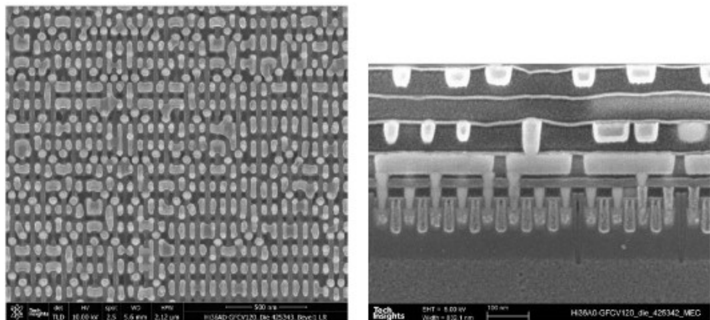

Figure 4: HiSilicon Kiron 9000s. SEM bevel (left) showing gate level and contacts. SEM cross section (right) across the gates showing metal gates and lower metal layers. TechInsights, 2023.

The gate pitch CDs are somewhat relaxed compared to other 7nm process nodes, but still shrunk compared to SMIC's N+1 version. This suggests the gate density is less versus other 7nm devices in the market. However, with other design-technology co-optimization (DTCO) features implemented on this die, like single diffusion break (SDB), the gate density gap is reduced.

Lower metal layers feature similar routing strategies to SMIC's N+1 version, but with smaller CDs bring this SMIC N+2 process closer to other 7nm nodes. These enhancements enabled SMIC to shrink its standard cell height (~5%) and standard cell area (~10%) compared to its N+1 implementation.

Discovering a Kirin 9000s chip using SMIC's 7nm (N+2) foundry process in the new Huawei Mate 60 Pro smartphone demonstrates the technical progress China's semiconductor industry has been able to make without EUV lithography tools.

The difficulty of this achievement also shows the resilience of the country's chip technological ability. At the same time, it is a great geopolitical challenge to the countries who have sought to restrict its access to critical manufacturing technologies. The result may likely be even greater restrictions than what exist today.

Could the Kirin 9000s, and SMIC N+2 node, revive Huawei smartphone sales and grant them a surge in smartphone shipments? Stay tuned to TechInsights for more insights and analysis.