Video Imaging of Silicon Chips

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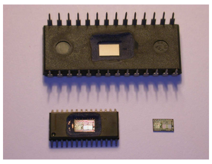
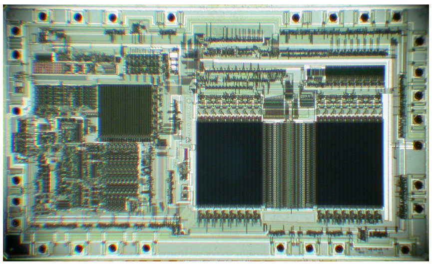
Standard imaging technique

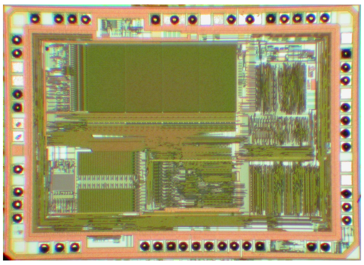


Prepared samples

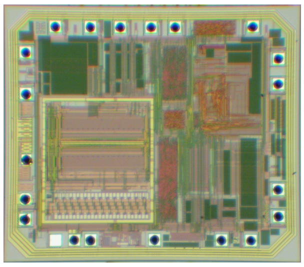
Visual observation under a microscope is the first step in semiconductor analysis. As feature sizes of transistors shrink each year, structures on the chip surface become more and more difficult to observe. Down to 0.8 µm technology, it was possible to identify all the major elements of microcontrollers – ROM, E^{2}PROM, SRAM, CPU and even instruction decoder and registers within the CPU. On chips built using 0.5 µm or 0.35 µm processes, one can hardly distinguish ROM, Flash and SRAM, whereas on chips with 0.25 µm or smaller transistors, almost nothing can be seen. This is caused not only by the small feature sizes, but most of all by multiple metal layers covering the chip surface (up to eight on modern 0.13 µm chips).



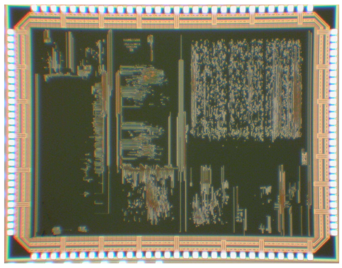
MC68HC705P6A, 1 µm



PIC16F77, 0.5 µm



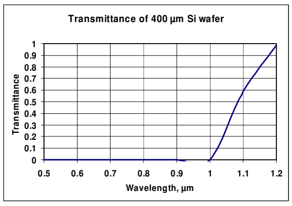
MSP430F1121A, 0.35 µm



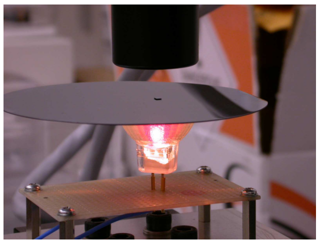
XAP Springbank, 0.18 µm

Backside imaging

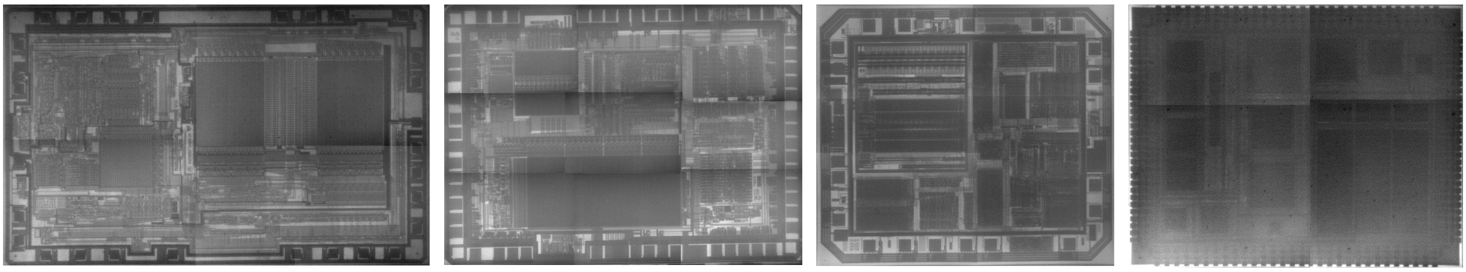
One approach is to use infrared light, either reflected or transmitted. Silicon is almost transparent to photons with wavelengths >1100 nm. A special infrared camera was used for taking the images below, a Hamamatsu 2741-03 with 400 nm – 1800 nm sensitivity and 700 lines resolution. A standard halogen lamp was used for illumination with a silicon wafer used as infrared filter. Using a Mitutoyo FS60Y microscope with NIR objectives improved quality and brightness of the images.



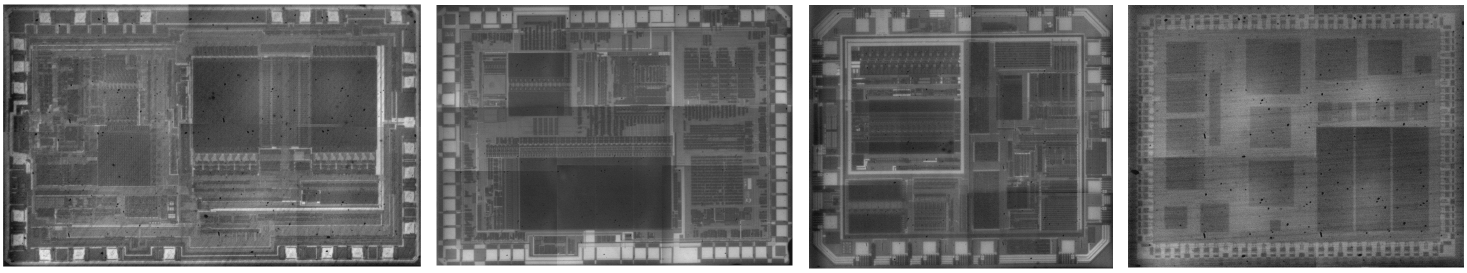
Transmittance of bulk Si



Transmitted light setup



Transmitted infrared light backside images of microcontrollers MC68HC705P6A, PIC16F77, MSP430F1121A and XAP Springbank



Reflected infrared light backside images of microcontrollers MC68HC705P6A, PIC16F77, MSP430F1121A and XAP Springbank

Reflected light gives better contrast, as it does not pass through multiple metal layers. For 0.5 µm and smaller technologies, much more information is revealed than from a normal image.
Another useful application of backside imaging is extraction of ROM content. On the front side, transistors are shielded by the top metal layer, whereas through the back side transistors are clearly visible.

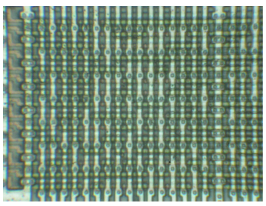
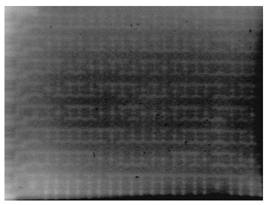


Image of the ROM



Reflected NIR image

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