AccessionIndex: TCD-SCSS-T.20251003.001
Accession Date: 3-Oct-2025
Accession By: Dr.Brian Coghlan
Object name: Early calculator chips
Vintage: 1971
Synopsis: Integrated circuits for early desktop and hand-held calculators.

Description:
In January, 1971, Mostek's released the first "calculator-on-a-chip" product, the MK6010 [1][2][3], a nail-biting adventure for the then small company. From [4]:

The Chip

Mostek engineers had to make history. By 1970 the microcomputer circuit industry was involved in a heated race to develop smaller circuits and reduce the number of circuits contained in calculators. Those in the industry knew that one day a single-chip calculator would be invented. The only questions remaining were when and by whom?

The answer came in November, 1970 from a group of supercharged engineers who worked for a little-known custom circuit design company in Dallas-the Mostek Corporation. How could this industry infant (50 employees) come up with the design of the decade, set the electronic world on its ear and beat the giants of the industry in both the United States and Japan at their own game?

According to those who did it, the answer was simple. Mostek had to do it to stay alive as a company. *"Business had just absolutely cratered,"* said Dave Leonard who, as part of a four-man design team designed the first single-chip calculator. *"Our total billings in December, 1970, for example was $50,000. That was engineering fees for work done on a custom circuit."*

The future of the company was uncertain in May, 1970 when Berry Cash, vice-president for marketing, visited the Tokyo offices of the Nippon Calculating Machine Company. A month before, Canon, Inc. had introduced a *"pocket-sized"* calculator which used three circuits and weighed 1.8 pounds. Nippon wanted to introduce a model that was smaller, lighter and less expensive to produce. And, Nippon wanted Mostek to put the calculator's circuit on a single-chip. Nippon agreed to let Mostek work on the idea and signed a contract which called for Mostek to begin supplying the circuits by mid-November.

The Mostek design group set to work on the circuit and decided to do what no other company had done before-to design a calculator circuit which fit on a single-chip. According to Leonard, the group gained their motivation from the fact that Nippon had agreed to buy 60,000 copies of their circuit for $30 each. *"The company needed that money,"* said Leonard, *"and it needed that product. That fact had a very positive influence on our work."* Dietrich Erdmann, now vice-president of Mostek International, had done some initial work on the logic system with Japanese engineers earlier in the year. Gaynell Lockhart took over the logic design job from Erdmann. Both he and Leonard had experience in calculator circuits with another company. The race began!

The group had allocated six weeks to design the layout for the circuit. But the first circuit design failed preliminary testing and instead of six weeks, the effort took three months. By the time the second design passed the initial tests and was ready for production, October had arrived. Time was literally running out for Mostek and the design team was working almost around the clock to finalize the design for production. By the time the chip was ready for production, November had arrived and the design team decided to speed up the process by putting Richard Petty, the layout engineer, engineering ruby and other plans on a plane for California where he would hand carry the plans to a contractor for mask production. Petty would then fly to Mostek's production facility in Worcester, Mass. where the chip was to be made.

In mid-November it was time for Petty to come home with the final product. *"About 10 one evening, we set up for testing and waited for Petty to walk in the door,"* Leonard said. About 10 to 15 people had gathered, including Le Kepley, a young test engineer who had been asked to help with the test. Petty walked in with the finished product and the testers hooked the chip to a calculator. *"We punched the `Clear' button and it cleared,"* said Kepley. *"We added and it added; we subtracted and it subtracted; and then everyone started plugging numbers into it-adding, subtracting, multiplying and dividing. The whole thing was incredible,"* said Kepley. A cheer went up and then applause. For Mostek as a company, it was the Super Bowl World Series and Triple Crown rolled into one.

The MK6010 was followed by the MK5010P, MK5011P, MK5012P, MK5013P, MK5014P and MK5015. The latter three were advertised as: "***MK5013/MK5014P** IC pair; four-function 12-digit calculator with display circuitry, 1 memory, automatic constant, selectable 5/4 roundoff or truncate, leading-zero blanking. **MK5015P** Interfaces between MK5013/14 set and Seiko 102 printer*" [5]. The MK5015P was used, for example, in the 1972 Commodore CBM US-121P 12-digit desktop calculator that provided 5/4 rounding, a memory function and an electronic printer. This Collection holds an unused MK5013/MK5014 chipset, see Fig.5. There are active efforts to reverse engineer such chips, e.g. by Ken Shirriff [6][7], to quote:

> Early calculator chips were very strange architecturally, using serial arithmetic. Later, they became more like microcontrollers, running an instruction set internally … for a microcontroller-style chip, you would see a ROM on the die, where the instructions are stored. But for a hardwired chip like the MK5010P, there's no ROM.

And another by Joerg Woerner [8]:

> I'm now working on the MK5010, MK5011, and MK5012 – early single-chip calculator circuits tracing back to the famous MK6010 made for Busicom. The MK5013/MK5014/MK5015 chipset will follow next year. The MK5010-12 chips are using "hardwired" logic and – as Ken mentioned – a serial 1-bit adder with BCD correction. There is shift-register memory for 2 numbers of 12 digits, each on the chip. See attached a die photo of the MK5010P {Fig.1}. Based on the timeline and functionality of the MK5013/MK5014, I'm almost positive that these chips use hardwired logic, too. I usually reverse-engineer calculators with chips from interest, have the chips de-capped and when I think that I understand them, I operate them one my debug platform.

And again by Joerg Woerner [8]:

> I couldn't resist and just measured into a MK5013/MK5014 chipset. I usually differentiate between *Register-Processors* (working on n-digit numbers with one instruction) and *Digit-Processors* (working on one digit a time, typical CPU/Microcontroller system). All Digit-Processors I'm aware of are "ROM-based" designs. Register-Processors are either "Hardwired" or "microprogram ROM-based". My 30-min findings:
> - Design uses a 2-Phase clock – typically used for shift-register data storage in Register-Processors (RP)
> - Design has only Fix-Point, no Floating-Point number representation → RP
> - Really bad behavior if you sum numbers in Memory while switching number of Decimal Points
> - [DP0] 34 M+, [DP2] 12 M+, [DP4] RM → 0.1234 → Hardwired RP
>
> I don't see "Instructions" going back and forth between the two chips, only timing signals and numbers. One chip is doing the digit strobes for 8 digits, the other one the segments and digit strobes for the other 4 digits → Hardwired RP. One Digit Time is four clock cycles → Bit-Serial Adder. One Scan Cycle is always fifteen Digit Times (12 digits, Sign, Housekeeping) → Hardwired RP. Output signals are *"Japanese-style"*, meaning this is a Busicom-originated design, most likely the MK6018/6019 chipset for Busicom Exec *121-DK*. MK6018 would indicate a 1971 design (MK6020 is HP35 = 1971) – before Mostek did microprogram-based calculator design. I'm almost positive that these chips are hardwired Register Processors, de-capping will show.

And again by Joerg Woerner [8]:

> Mostek was selling MK6xxx as Customer-specific chips and MK5xxx as "catalog chips". Sometimes, when exclusivity ended, the MK6xxx chips morphed into MK5xxx chips. The de-capped MK5011P sports an MK6010 marked die.
>
> **1st Generation:** MK6010 = original chip for *Busicom* desktop. 25V process, MK6010L = 15V process for *Busicom* handhelds.
> MK5011 = MK6010, MK5012 = MK6010L, MK5010 = MK5012 "stripped" from 12 to 10 digits.
> **2nd Generation:** MK5013/MK5014 Chipset for 12-digit calculators with memory and 5/4 rounding – probably MK6018/6019.
> MK5015 = Printer Chip for MK5013/MK5014 chipset.
> **3rd Generation:** MK5020 = drop-in replacement for TI TMS0100 but different architecture (but ROM-based Register-Processor, too).
> TMS1802 was introduced before MK5020, TI later renamed it to TMS0100 family. Same die, different ROMs and PLAs. Mostek "copied" the functionality and pinout of the TMS0100 family to allow easy and quick design-ins.

And again by Joerg Woerner [8]:

> We consider three chipsets from 1969/1970 "first generation": Rockwell/Sharp, TI/Canon, GI/Sanyo
>
> And three "calculator-on-a-chip" from 1970/1971 "first generation":
> - Mostek MK6010/Busicom
> - GI 250/Litton Royal
> - TI TMS1802/Various
>
> The MK6018/6019 from 1971 with the MK6025 Printer Expansion (1972) is one of the many "second generation" chipsets.

Many calculator chip cores were flexible enough to engender a multiplicity of derived calculator cores. Moreover, most calculator chip cores included a mask programmable

ROM, so that one core could result in numerous chip types that were different only in the ROM contents, sometimes yielding surprisingly inventive products, again see [6][7]. Furthermore, a few calculator cores were repurposed to create special device types. For example, the Texas Instruments TMS0117 [9] and National Semiconductor MM57109 [10] in this Collection (see Figs.6-7) were decimal arithmetic units derived from calculator cores.

TMS0117 is a member of the TMS0100 family, using “low-level” commands as keyboard inputs.

Also, from Eric Smith:

The mentioned National Semiconductor MM57109 "Number Cruncher" is a specific masked ROM MM5799, which has a "digit architecture". The later MM57409 "Super Number Cruncher" is a COPS 400 series part (I'd have to check my notes for the specific p/n), also a digit architecture. AFAIK, National Semiconductor didn't make any register processors.

Both were intended to act as coprocessors, and indeed were used by Brian Coghlan and his colleague Graeme Taylor to construct two really useful machines [11].

Many thanks to Brian Coghlan for donating these items. Also many thanks to Joerg Woerner and Ken Shirriff for their engagement in uncovering these interesting details.

The homepage for this catalog is at: https://www.scss.tcd.ie/SCSSTreasuresCatalog/
Click *'Accession Index'* (1st column listed) for related folder, or *'About'* for further guidance.
Some of the items below may be more properly part of other categories of this catalog, but are listed here for convenience.

Accession Index	Object with Identification
TCD-SCSS-T.20251003.001	Early calculator chips. Integrated circuits for early desktop and hand-held calculators. 1971.
TCD-SCSS-T.20251003.001.01	Mostek MK5013P calculator-on-a-chip. 1971.
TCD-SCSS-T.20251003.001.02	Mostek MK5014P calculator-on-a-chip. 1971.
TCD-SCSS-T.20251003.001.03	Texas Instruments TMS0117 arithmetic processor. 1973.
TCD-SCSS-T.20251003.001.04	NatSemi MM57109FAN/N ‘number cruncher’. 1977.
TCD-SCSS-X.20250916.001	Dr.Brian Coghlan's Collection of Early Microprocessors. An extensive and nearly complete set of unused 1970s microprocessor chips, most accompanied with documentation, some with demonstration boards. 1971.

References:

1. Wikipedia, *Calculator*, see:
https://en.wikipedia.org/wiki/Calculator
Last browsed to on 3-Oct-2025.

2. Vintagecalculators, *The Story of the Race to Develop the Pocket Electronic Calculator*, see:
http://www.vintagecalculators.com/html/the_pocket_calculator_race.html
Last browsed to on 3-Oct-2025.

3. Vintagecalculators, *The Arrival of the "Calculator-on-a-Chip"*, see:
http://www.vintagecalculators.com/html/the_calculator-on-a-chip.html
Last browsed to on 3-Oct-2025.

4. Mindspring, *The Chip*, see:
https://web.archive.org/web/20120121071408/http:/www.mindspring.com/~mary.hall/mosteklives/history/10Ann/thechip.html
Last browsed to on 3-Oct-2025.

5. Mostek, *Mostek Integrated Circuit Guide*, see:
https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002/Mostek-Integrated-Circuit-Guide-1974.pdf
Also: https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002/Mostek-CalculatorChips-Ad-SMD102238-XL.pdf
Last browsed to on 3-Oct-2025.

6. Sinclair, *Sinclair Scientific*, see:
https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002/SinclairScientific-VintagecalculatorsCOM.pdf
Also: https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002//SinclairScientific-Brochure.pdf
Last browsed to on 3-Oct-2025.

7. Ken Shirriff, *Reversing Sinclair's amazing 1974 calculator hack*, see:
https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002/Reversing-Sinclairs-amazing-1974-calculator-hack-KenShirriff.pdf
Last browsed to on 3-Oct-2025.

8. Joerg Woerner, personal email communication to Brian Coghlan, 2025.

9. Texas Instruments, *Texas Instruments TMS0117 Arithmetic Processor*, see:
https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002/TexasInstruments-TMS0117-ArithmeticProcessor-datasheet.pdf
Last browsed to on 3-Oct-2025.

10. National Semiconductor, *National Semiconductor MM57109 Number Cruncher*, see:
https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002/NationalSemiconductor-MM57109-NumberCruncher-datasheet.pdf
Last browsed to on 3-Oct-2025.

11. Brian Coghlan and Graeme Taylor, *Autograph digitiser/processors*, see:
Mk.1: https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002/Autograph-Mk1.pdf
Mk.2: https://treasures.scss.tcd.ie/hardware/TCD-SCSS-T.20251002.002/Autograph-Mk2.pdf
Last browsed to on 3-Oct-2025.

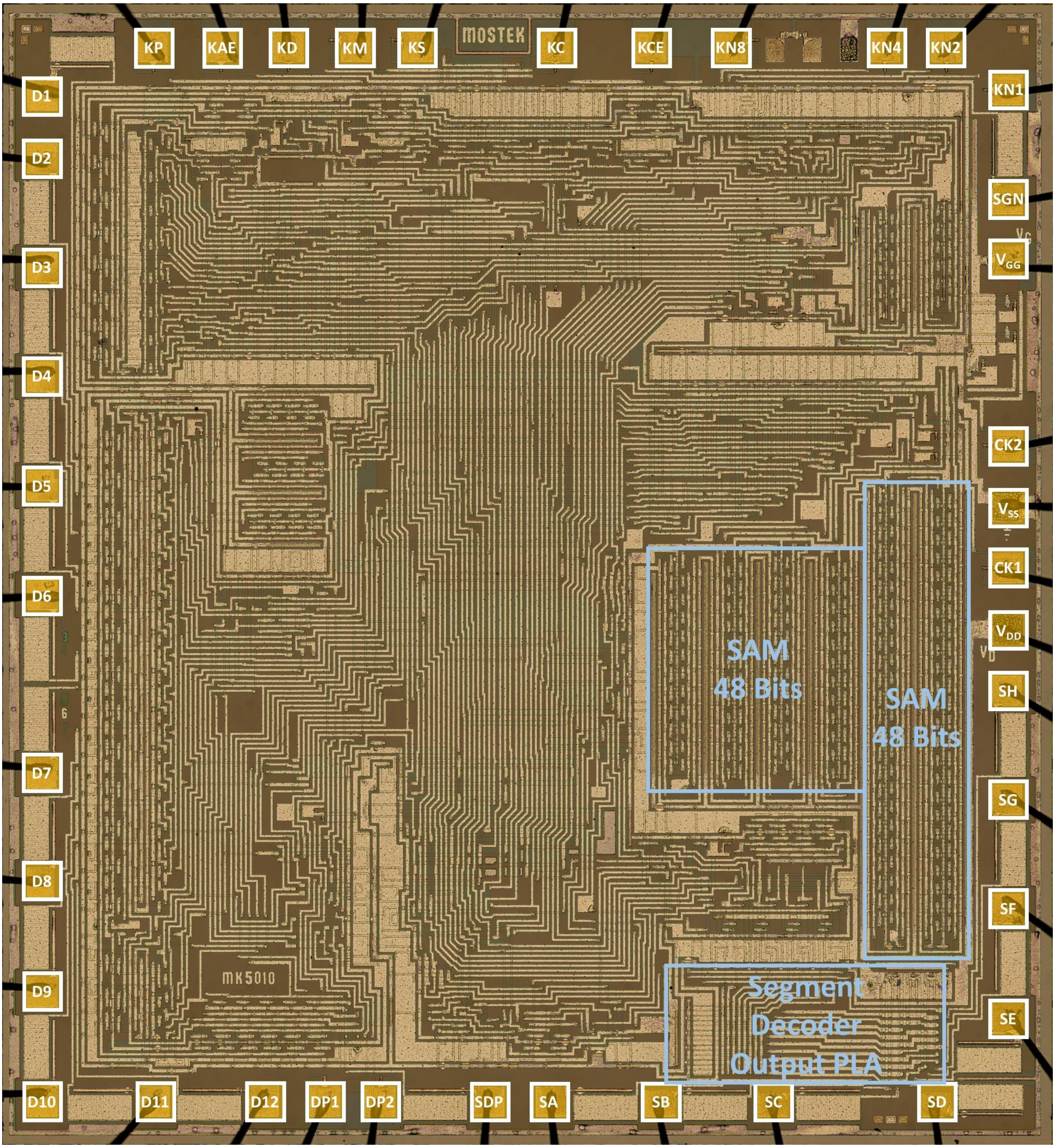

Figure 1: Mostek MK5010 die micrograph, courtesy Joerg Woerner.

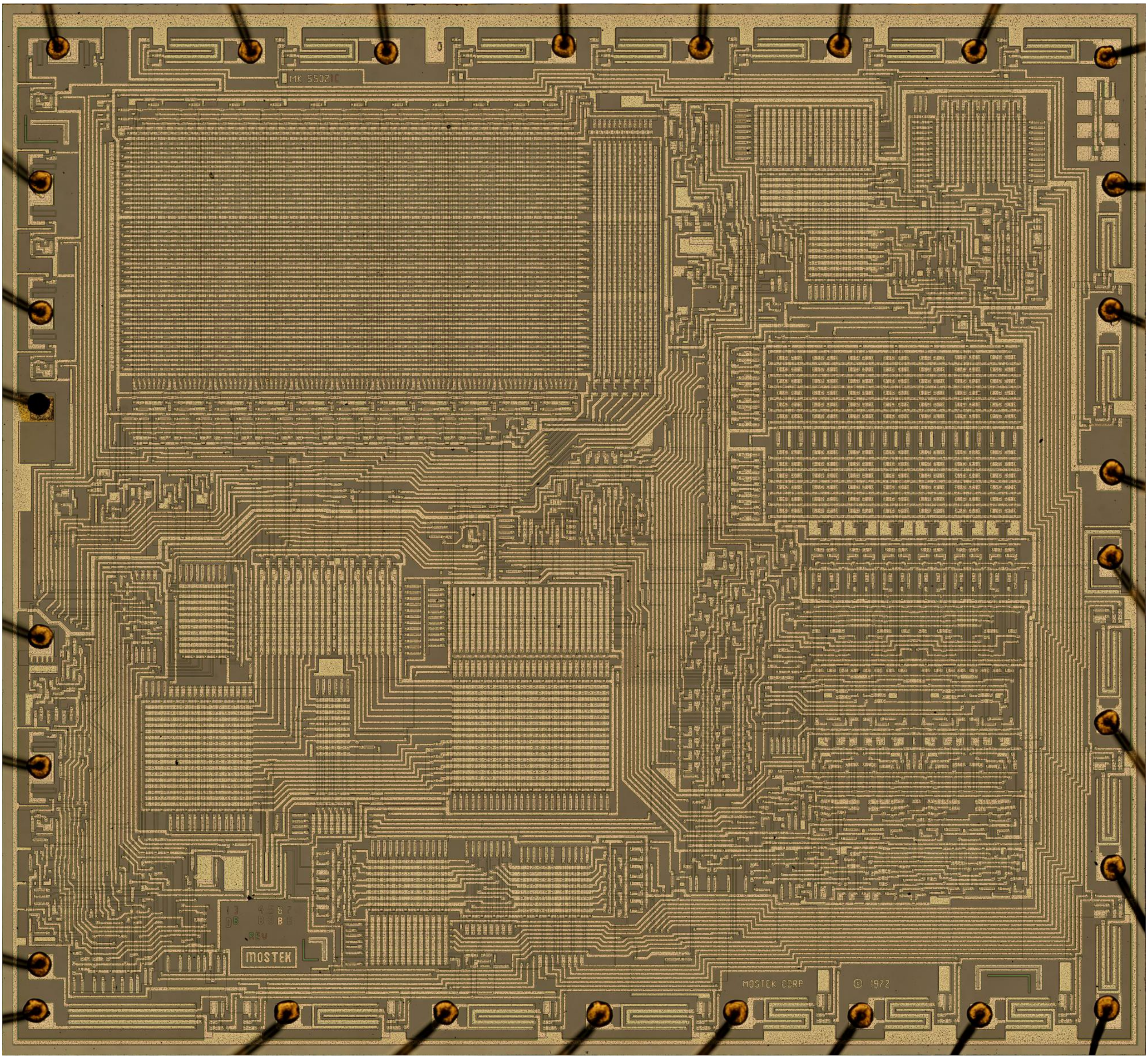

Figure 2: Mostek MK5021 die micrograph, courtesy Joerg Woerner.
ROM is at upper left, shift-register RAM is at 3 o’clock, PLA structures are at lower left (courtesy Ken Shirriff).

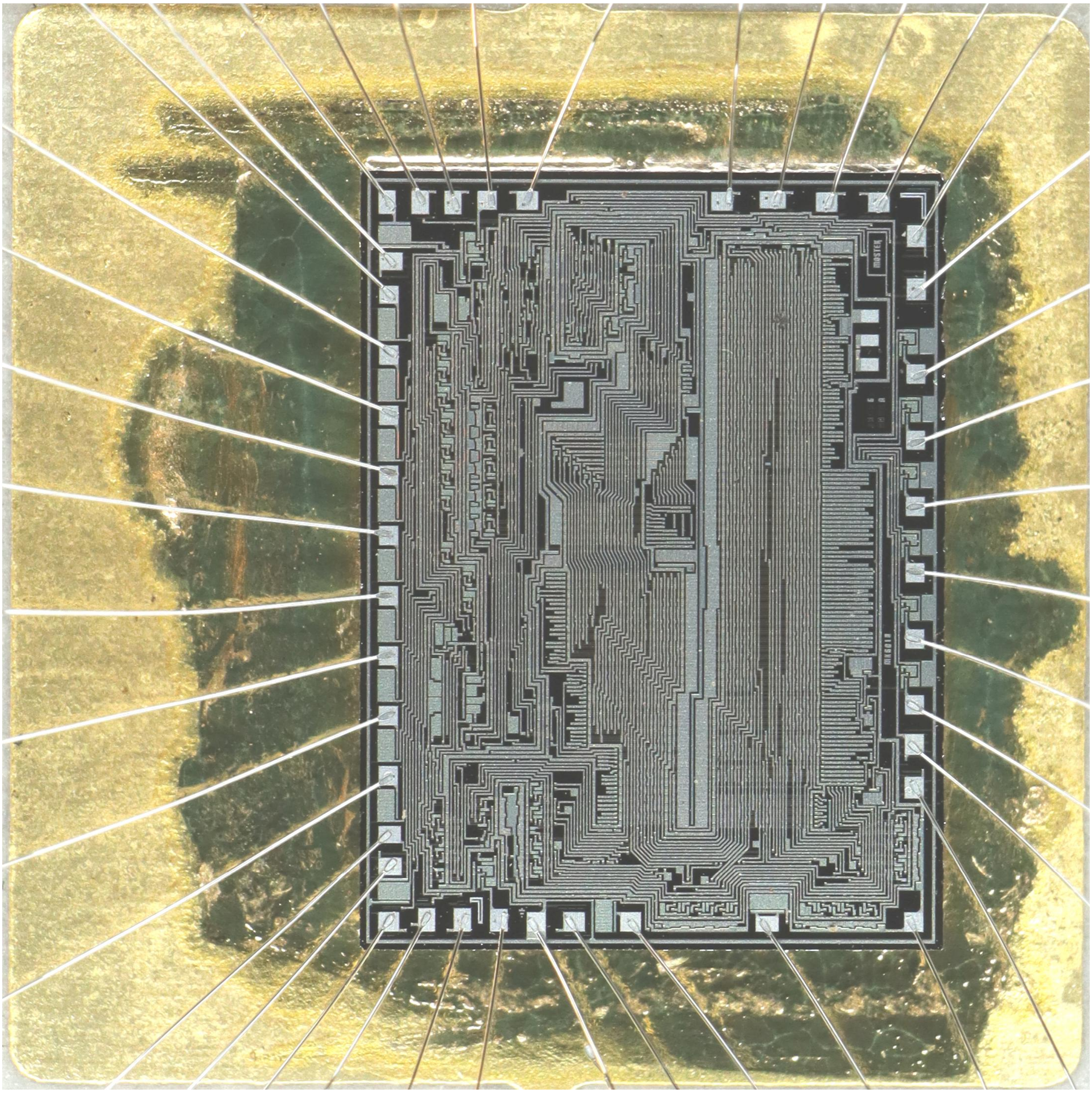

Figure 3: Mostek MK5013 die micrograph, marked 5013 on die (not 6018).
Courtesy Joerg Woerner, 23rd October, 2025.

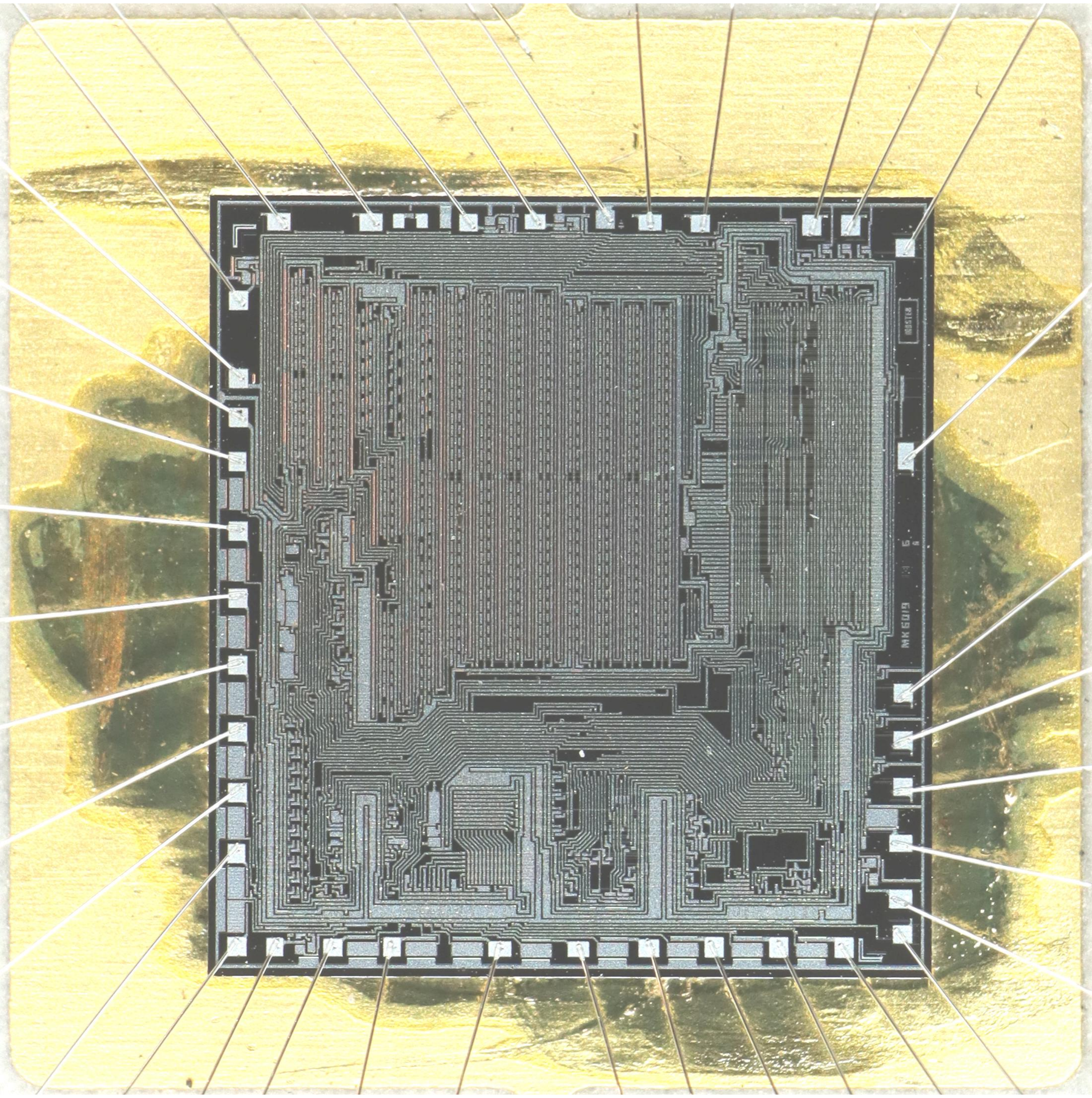

Figure 4: Mostek MK5014 die micrograph, marked 6019 on die
Courtesy Joerg Woerner, 23rd October, 2025.

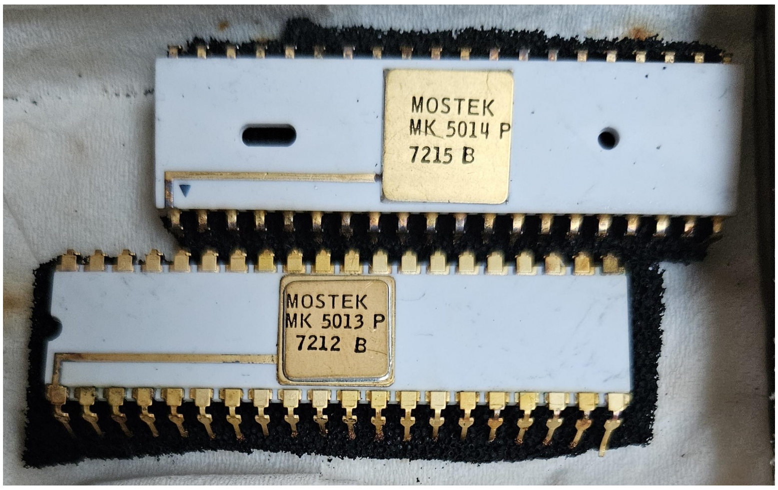

Figure 5: Mostek MK5013 and MK5014 front view

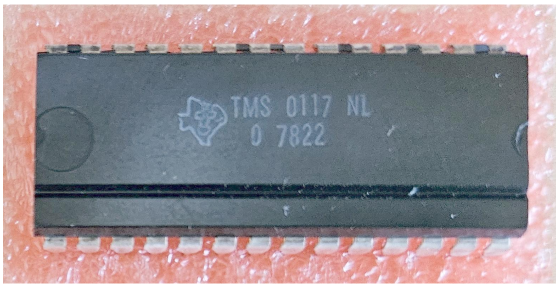

Figure 6: Texas Instrument TMS0117 front view.

Figure 7: National Semiconductor MM57109 front view.