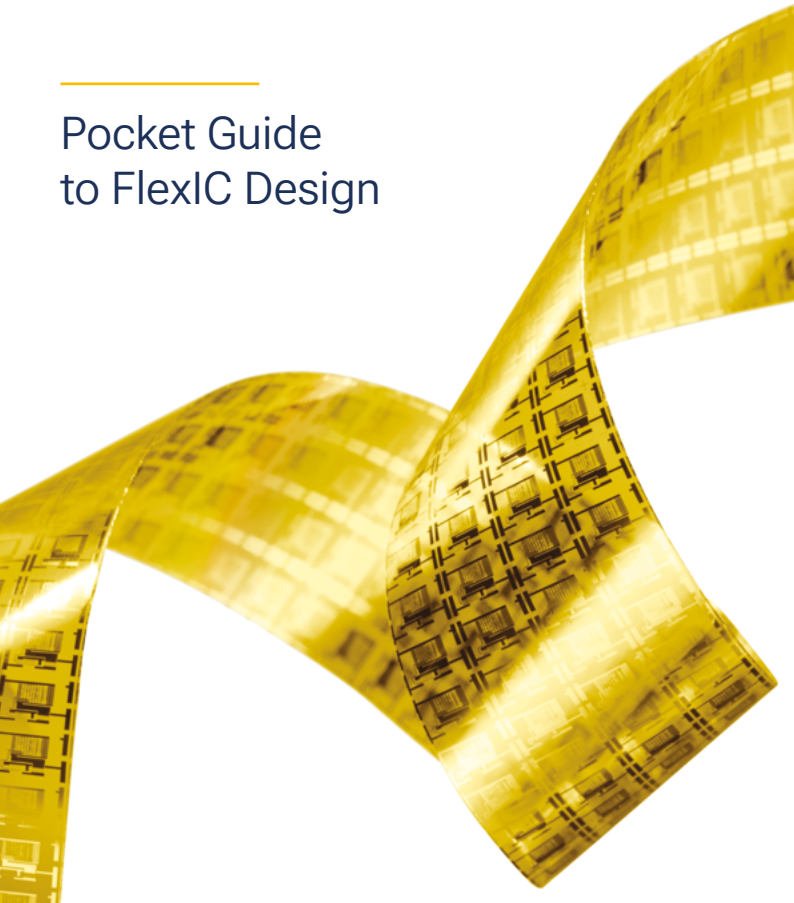
Pragmatic

Pocket Guide to FlexIC Design



Introducing Pragmatic

Pragmatic's revolutionary semiconductor manufacturing process takes flexible integrated circuits (FlexICs) from tape-out to delivery in around four weeks, at a fraction of the cost of silicon.

By omitting the most resource-intensive parts of traditional production processes, our unique, silicon-free fabrication achieves production cycle times of less than 48 hours. It also consumes significantly less water and energy – making Pragmatic one of the most sustainable semiconductor manufacturers in the world.

www.pragmaticsemi.com

What exactly is a FlexIC?

FlexICs use thin-film transistor (TFT) technology in combination with conventional semiconductor processing to deliver the world's most complex flexible circuits.

Delivered on state-of-the-art, 300mm wafers, FlexICs are unique amongst semiconductors, and require no packaging or thinning. From memory to connectivity or sensing functionalities, they can be used in conjunction with devices such as displays and sensors to create novel solutions for countless applications, particularly where simple state machines or small control logic is required.

FlexICs are ideal for use wherever form factor and cost are critical, and excel where chip size is physically limited by factors such as I/O pads or array size, rather than complexity of logic circuitry.

Specifications

Transistors	Metal oxide thin film transistor	n-type FET
	Minimum channel dimension	600 nm
Resistors	Dedicated resistor layer	200 kΩ/sq
Capacitors	High-k dielectric MIMCAP	2.7fF/μm^2
Interconnects	Metal routing	Four layers
Physical	Total thickness	~30 μm
	Minimum bend radius	5mm
Turnaround	Tape-out to delivery	Approx. 4 weeks

Simplicity: the key to FlexIC design

Designing for FlexICs is simple. It's almost the diametric opposite of designing for silicon, where high costs and long development times dictate that your chip be suited to as many workloads as possible: designing for FlexICs is altogether more agile.

Unlike silicon, low-cost production and rapid turnaround means you can afford to get a design out, test it and hone the functionality for your unique use case, accelerating time to market and reducing the costs of the development phase.

Furthermore, FlexICs bring just enough performance and complexity to get the small jobs done. No more, no less. This, in combination with their flexible form factor, means they can be used in places where it would not be cost-effective – or even possible – to use silicon.

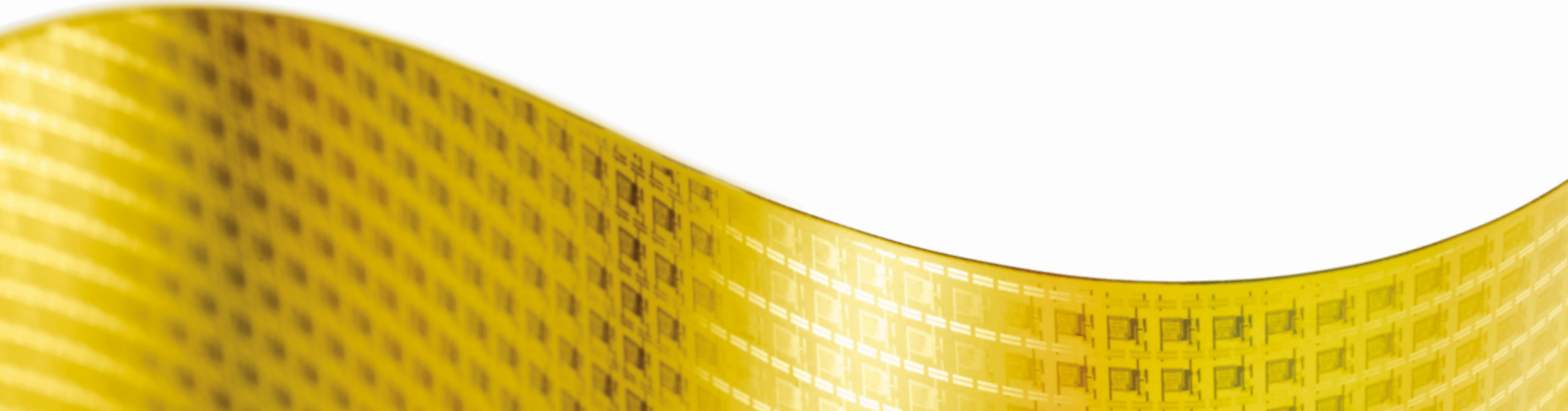
It's quick and easy to transfer your silicon skills to the design process. The layout is simple, so you can design faster, using the process design kit (PDK).

Process Design Kit: Helvellyn 2.1.0

Our process design kit (PDK) is simple, straightforward and gives you everything you need to successfully design for FlexIC technology. It's also fully compatible with industry-standard electronic design automation (EDA) tools, such as Synopys, Siemens and Cadence.

- Primitive device library
- Design rule and layout verification checks
- Technology data and rules files
- Parameterized cells to enable the creation of customized instances and increase productivity (within the EDA tools)
- Device models compatible with leading EDA simulation tools

Contact sales@pragmaticsemi.com to request PDK access.



Case study: PlasticArm

2020 saw the birth of PlasticArm – an ultra-minimalist Cortex-M0-based SoC and the world's first fully functional, non-silicon Arm processor.

The result of blue-sky research by Arm and Pragmatic, the chip supported a 32-bit Arm microarchitecture, had 128 bytes of RAM and 456 bytes of ROM, and was twelve times more complex than contemporary state-of-the-art flexible electronics.

It was implemented in Pragmatic's 0.8µm metal oxide TFT technology using just 39K NAND2 gate equivalents in an area of 59mm^2.

The processor contained a 32-bit Arm Cortex-M CPU and a Nested Vector Interrupt Controller (NVIC), and was connected to its memory through the interconnect fabric (AHB-LITE). The external bus interface provided a General-Purpose Input-Output (GPIO) interface to communicate off-chip with the test framework.

Read the full paper

A natively flexible 32-bit Arm microprocessor, Ozer et al, 2021: http://www.nature.com/articles/s41586-021-03625-w

Case study: Malodour classification with FlexICs

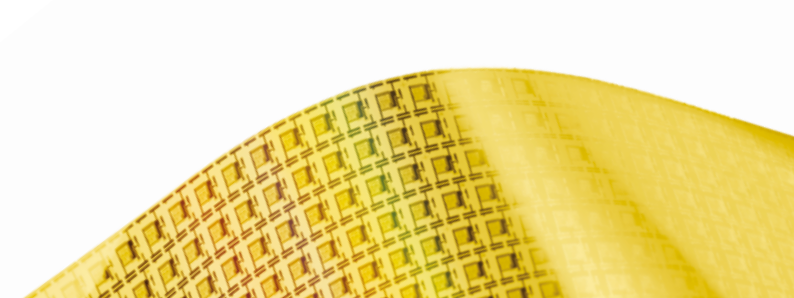
Pragmatic, in collaboration with the University of Manchester, Unilever and Arm, published a paper in Nature Communications detailing a research project on malodour classification – the world's first to demonstrate a system integrating an e-nose sensor, sensor interface and a predictor hardware in low-cost flexible electronics.

Using machine learning hardware based on FlexICs, the team developed a custom-designed classification system to objectively rate the funkiness of test subjects' personal aroma. The decision-tree-based machine learning model was trained using data obtained from human armpit odour assessors, and returns a numerical value based on the strength of the odour.

Beyond the initial scenario of 'smelling' body odour, the solution has potential application in a wide range of areas from food freshness, based on the presence – or otherwise – of odours that indicate deterioration, to detecting surgical site infections, based on changes in the volatile organic compounds emitted during the healing process.

Read the full paper

Malodour classification with low-cost flexible electronics, Ozer et al, 2023: www.nature.com/articles/s41467-023-36104-z



Simply intelligent