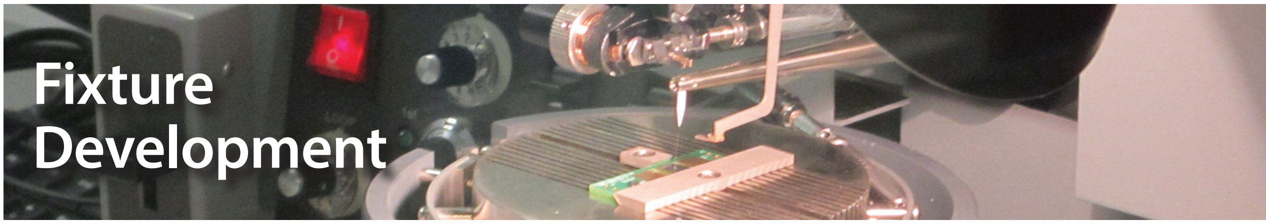


# *Fixture Development for Prototyping Microelectronic Assemblies*

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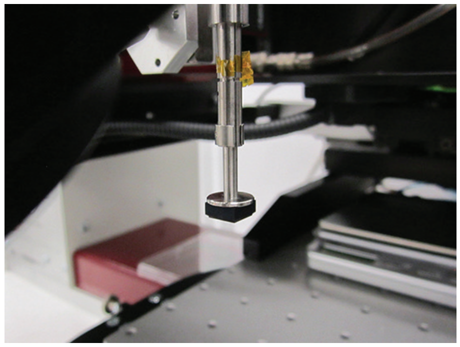
DEVELOPING MICROELECTRONIC ASSEMBLIES for new products can be challenging. The market opportunities are widely varied and the applications tend to be highly specialized. These unique applications can involve complex sub-assemblies. As a result, fixture development becomes a key element in the product development cycle. Fixture development for early prototypes is a pivotal point in the product development cycle because these prototypes need to be representative of the final product. Balancing the requirements for precision fixtures against a proposed timeline commitment can be challenging.

There are three distinct phases of the product development cycle for complex sub-assemblies: proof of concept, early prototype (often referred to as simply "prototype"), and production representative. The "proof of concept" phase, as the name implies, demonstrates whether the concept is valid and if it will function as intended. In the "prototype" phase functionality has already been demonstrated. The objective is to build samples that more closely resemble the finished product and can be placed on life test or sent to customers. This phase also serves as the opportunity to demonstrate manufacturability. Finally, the "production representative" phase produces samples that represent the finished product. They are often produced on production intent tooling to verify manufacturing process capability and product functionality.

For the proof of concept phase processes are often manual, so if tooling is required at all it is minimal. For production representative samples, the design is frozen, the product is tested and proven, and the soft tooling is already developed. The prototype phase presents the biggest challenge for tooling. For prototype sample builds the project schedule is usually compressed. It is important to fabricate part-specific fixtures quickly enough to satisfy the schedule, but precisely enough to validate the process and the product. Taking advantage of advanced design tools like solid modeling and 3D printing can help accelerate this step.



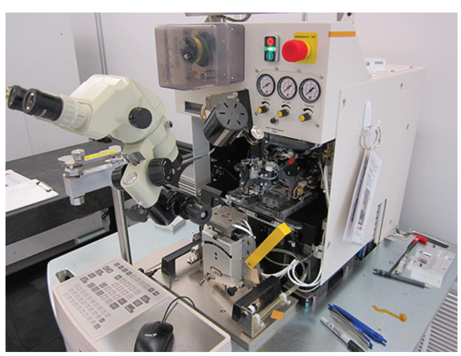
**Plastic die attach end-effector makes contact with the parts being assembled.**

During the proof of concept phase it is often best to use as many manual processes as possible. For example, if parts need wire bonding for interconnects, a manual wire bonder can be used to satisfy that need. During such manual processes fixturing is not necessarily required. If dispense is part of a required process, using a simple EFD hand dispenser that does not require fixturing is an effective solution. The same is true if the product requires die attach. If possible, a manual system is implemented without custom fixtures.

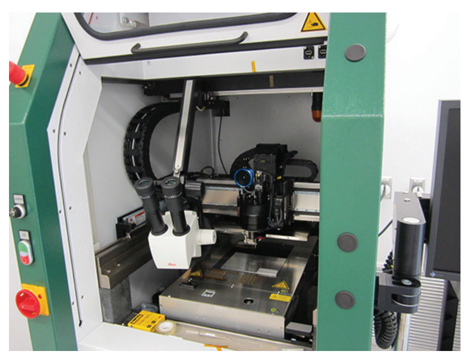
In almost all cases, once the project is moved into the prototype build phase it becomes necessary to move to highly automated production processes. Wire bonding processes may be moved to a K&S iConn gold ball bonder, or a Hesse fine gage aluminum wire bonder. Die attach processes would likely be moved to a Besi Datacon. Regardless of the automated production process solution, product-specific tooling is inevitable. Both end effector tools and part-specific fixtures are required to securely hold the part and properly present it to the process system.

End effector tools are the tools that fit into the process equipment and make physical contact with the parts or components being assembled. For example, the die attach end effector tool is a small metal stylus that matches the geometry of the die being picked up and placed. End effector tools may have vacuum holes that can pick and place a die without damaging it. In most MEMS sensor die applications this tool will also have certain areas known as keep out zones. These areas correspond with areas of the die that the tool must not contact. These tools are often designed to dimensions and tolerances in the submicron range and can take up to eight weeks for fabrication and delivery. Sometimes soft plastic tools can be used temporarily. Plastic tools generally have a shorter lead time so using them can cut the delivery time in half while hard tools are being fabricated in parallel.

**K&S Model 4700 Manual Wire Bonder.**

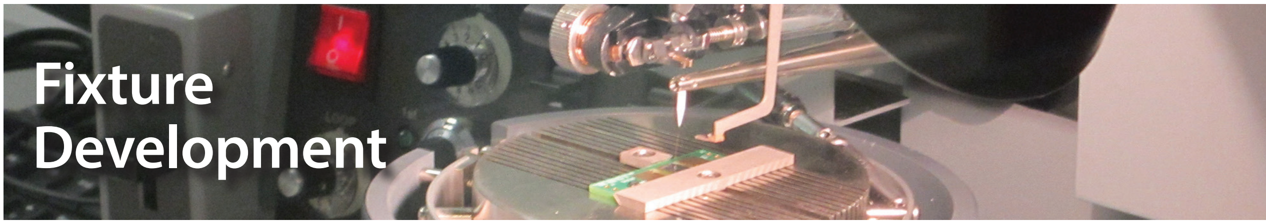


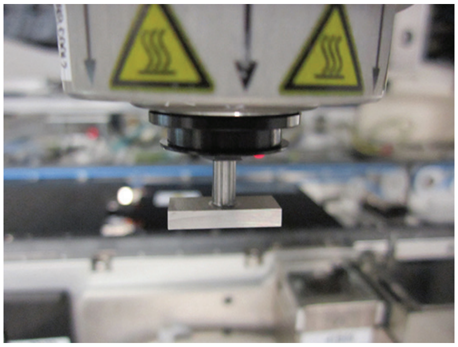
**K&S iConn Automatic Wire Bonder.**



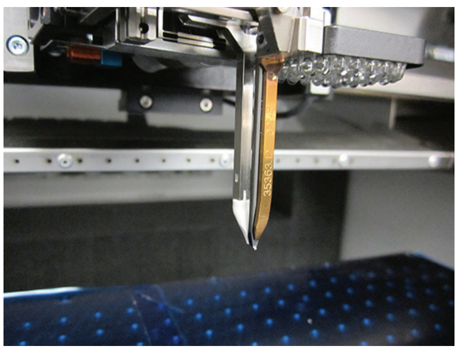
**Hesse Mechatronics Model BJ820 Automatic Wire Bonder.**

# Fixture Development

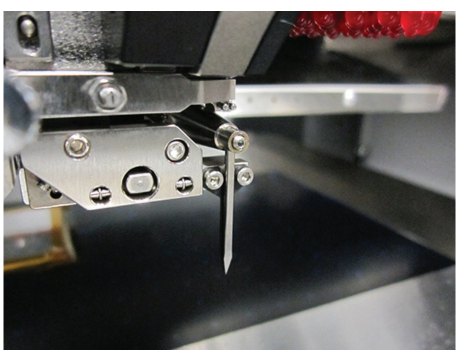




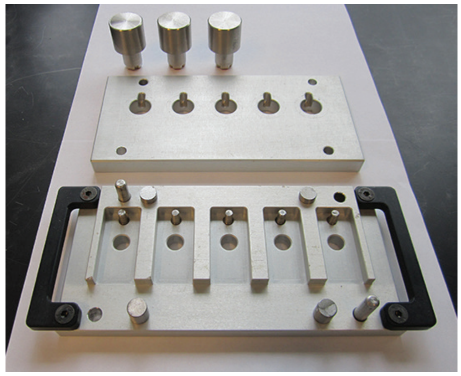
**Metal die attach end-effectors are preferred, but plastic devices generally have a shorter leadtime.**



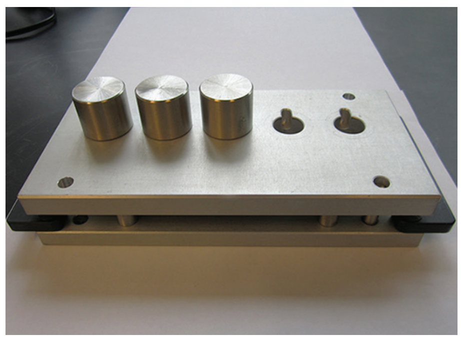
**Heavy Gauge Wire Bond Tool.**



**Once the project has been moved to the prototype build phase, wire bonding processes are moved to either to a fine guage wire bonder (shown) or a heavy guage wire bonder.**



**Bottom plate, top plate and weights of the fixture.**



**Assembled fixture.**

Process and part-specific fixtures for prototype sample builds can present a challenge to even the most veteran designer. Each fixture must be custom designed to fit the geometric features of the part and properly mate with the handling features of the automated process equipment. The fixture must present the part to the automated process equipment—for instance, the automated wire bonder—in such a way that it can perform the intended process to the specified tolerance while reducing part-to- part variation. Parallel efforts can be made to begin fixture design during the proof of concept phase: a strategy known as "starting with the end in mind". Unfortunately, more often than not, the project schedule does not accommodate proper fixture design.

Proper fixture design starts with a customer drawing and a top down approach. The critical dimensions and datum are derived from the drawing of the top most assembly of the part being built. Those critical dimensions and datum are then passed down, through the assembly, into the fixture to ensure that the part will meet the customer's design and drawing intent. Finally, the fixture is designed to mate with the automated process equipment. In cases where there is more than one process, if possible, the fixture is designed in such a way that multiple processes can be accommodated with a single fixture. For example, if a process requires die attach followed by a gel dispense it can be a substantial cost savings for the customer to use one fixture for both operations. This type of thoughtful design can be time consuming up front, but will save a considerable amount of time and cost downstream in the overall product development cycle.

SMART Microsystems often receives a project while it is still in the prototype phase. The schedule is highly compressed and the concept has not always been proven. The project requirements include prototype samples for testing and customer support. The desired sample quantities and precision requirements often dictate that manual die attach, wire bond, and dispense processes will not produce the required results. It is critical to remember that when a development project moves from the early proof of concept phase to prototype sample builds, there will be custom tooling required. Allocation of time and resources in the product development plan for tooling design and fabrication should not be underestimated.

*William Boyce is the Engineering Manager at SMART Microsystems. He is detail-oriented and is a hands-on engineering leader with a wide range of diverse skills from his background in automotive sensing. He has served in senior engineering roles over the last 19 years with accomplishments including: manufactured automotive sensors, leading new product development teams that created over $25M new revenue/year, certified in EIT and Six Sigma Green Belt, industry recognized expert in Al wire bonding, and designed and led metrology lab and machine shop at Sensata.*

*William has a Bachelor of Science in Engineering degree from the University of Rhode Island, and has been a member of the IMAPS New England Chapter for over 10 years.*