Engineering that Begins with the End in Mind

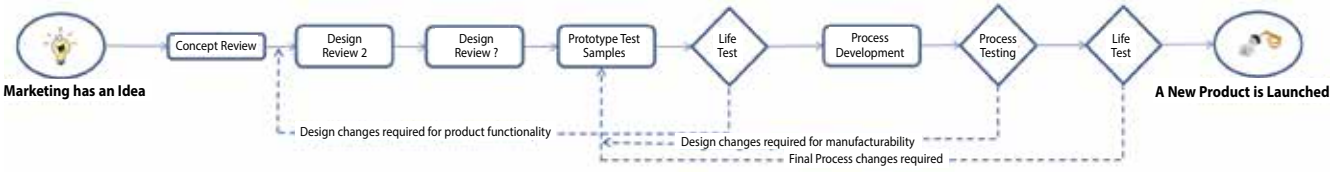
ENTERING THE MEMS SENSOR market with a new product can be a particularly daunting task. Even the most seasoned product development teams mistakenly rely on a traditional serial approach. For the fast-paced and demanding MEMS marketplace, this traditional product development cycle will not meet the market needs in terms of cost and timing. To encourage engineering that begins with the end in mind, **Test Early Test Often** and **Concurrent Engineering** are two strategies which can meet market demands. These product development strategies create quicker learning and shorter design cycles. By implementing these two strategies, product development teams can lower overall development time and cost for the MEMS sensor market.

The traditional product development cycle (PDC) often leads to projects running over budget and behind schedule. Traditional PDCs begin with several design iterations which include thorough design reviews at each stage. Each iteration is typically followed by models and simulations, which in turn are followed by more design iterations. These steps take place over an extended period of time, only after which the design is declared complete and subsequently "frozen". Samples constructed using the frozen design are tested, which results in the discovery of preventable flaws which then must be addressed with yet another design iteration.

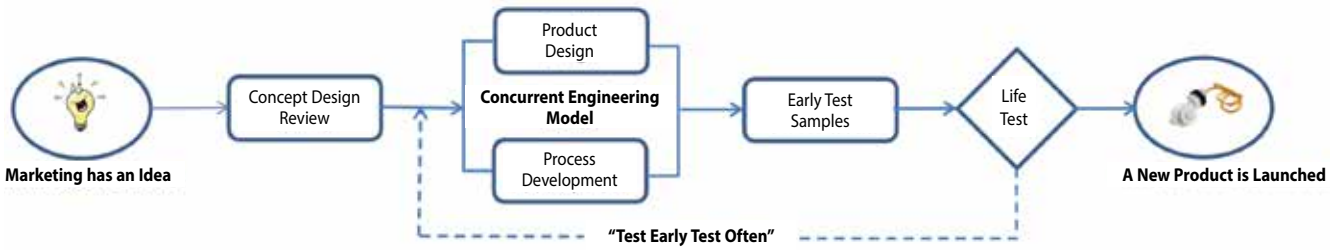
As the traditional PDC continues to iterate, the clock continues to tick, and the budget continues to deplete – meanwhile, the manufacturing process has yet to be considered. Most design teams reach the end of the design phase with enough fixes to get a functional product, but over budget, out of time, and without addressing manufacturability. This type of PDC is costly and the unnecessary serial iterations allow time for competitors to gain market entry first. More disadvantageous yet, without time left to establish the process portion of development, traditional PDCs can lead to manufacturing a product that is not sustainable.

The **Test Early Test Often** approach to product development addresses the flaws of the traditional PDC. This strategy shortens the overall PDC by employing targeted testing early in the development process. The Test Early Test Often approach uncovers weaknesses in designs by testing fundamental design and process assumptions before too much value is added to the part. In this strategy, requirements for new science are highlighted, potential issues are addressed before they become integrated into the process, and the overall cycle of iterative changes is shortened.

The Test Early Test Often strategy relies on low-cost modular samples to perform testing instead of relying on assembled prototypes. To test wire bonds, for example, a shake test on a costly end-of-design prototype sample would be performed in the traditional PDC. A low-cost modular sample, however, could provide valuable early data. This modular sample, such as a 50x50mm aluminum plate populated with 1 mil aluminum wedge bonds of a defined loop height and geometry, can be produced in a few days and subjected to a one hour 10g sinusoi-



The Traditional Product Development Cycle

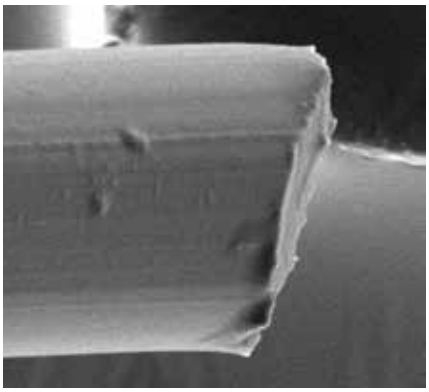


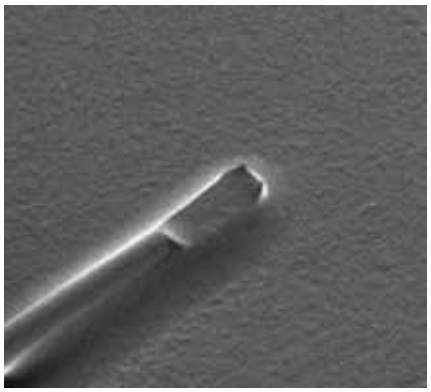
The Test Early Test Often Strategy Applied to the Product Development Cycle

dal vibration profile. Results (as shown in the SEM images at right) can be analyzed in multiple ways, including optical and acoustic microscopy, X-Ray, and SEM. The whole test can be completed in less than a week with the learning incorporated into the early stages of the design and process engineering.

The Test Early Test Often approach also takes advantage of rapid prototyping to implement targeted tests to create quicker learning. For example, assemblies can be made from high-temperature SLA materials to enable -40˚C to 125˚C thermal cycling. This allows for early understanding of possible CTE mismatch issues. If this test was dependent on the availability of injection-molded parts – as would be necessary in the traditional PDC – the learning gained would not be available in the early design iterations.

Another strategy to address the pitfalls of the traditional PDC is the **Concurrent Engineering** approach to product development. Concurrent Engineering promotes manufacturable design and reduces overall product development cost by creating synergies between design and process engineering groups. By beginning with the end in mind, this strategy encourages the design engineer to consider the process and the process engineer to consider the design. For example, Concurrent Engineering encourages a scaleable tooling strategy that can grow to last the life of the program. If production volumes are going to increase, tooling can be designed flexible enough to integrate a conveyor



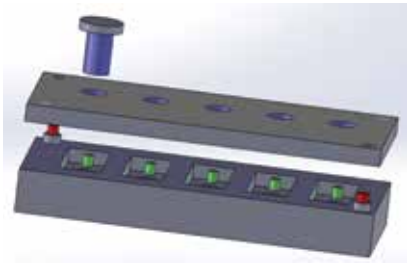


Scanning Electron Microscope (SEM) image of Al wire bond after test.

Environmental Life Test Chamber used to determine CTE mismatch issues.

feed later in the program. Lower capital investment is needed to implement a conveyorized solution since the tooling does not need to be redesigned.

When the design and process development is conducted concurrently, and early testing is performed, learning is quicker



Scalable Tooling Design

and the design cycles become much shorter. Implementation of Concurrent Engineering hand-in-hand with the Test Early Test Often strategy adds real, measurable value. These combined engineering strategies significantly lower overall development time and cost.

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