

Packaging and Application Trends in Flexible Electronics

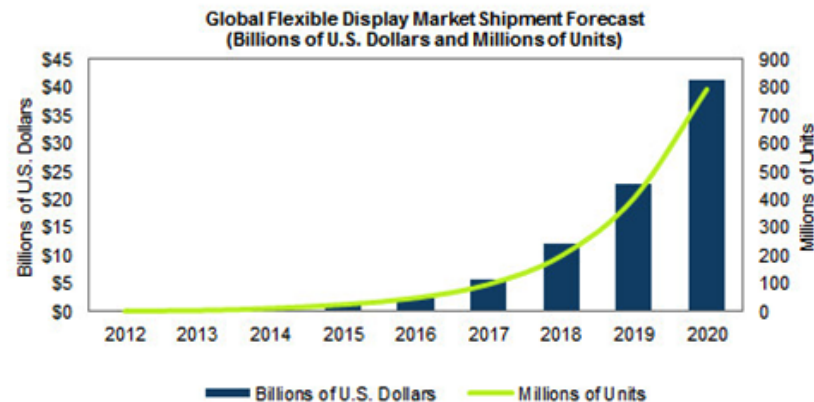
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Many Markets for Flexible Electronics

- **Displays**
 - OLED market projected to be \$4 billion market by end of decade according to NanoMarkets (lower volume than its potential due to high manufacturing cost)
 - Flexible displays, with applications from smartphones to giant screens mounted on buildings, projected by IHS to grow to \$41.3 billion (792 million units) in 2020
- **E-Textiles--textiles with electronic functions based on weavable e-fibers**
 - Applications in sensing (for health and fitness monitoring), warming (outdoor weather), displays and lighting, control (sleeve controls for personal electronics and woven rollable keyboards), logistic (with RFID)
 - \$1 billion market by end of the decade
- **Printed, organic, and flexible electronics**
 - IDTechEx projects market growing from \$16 billion in 2013 to \$76.8 billion by 2023



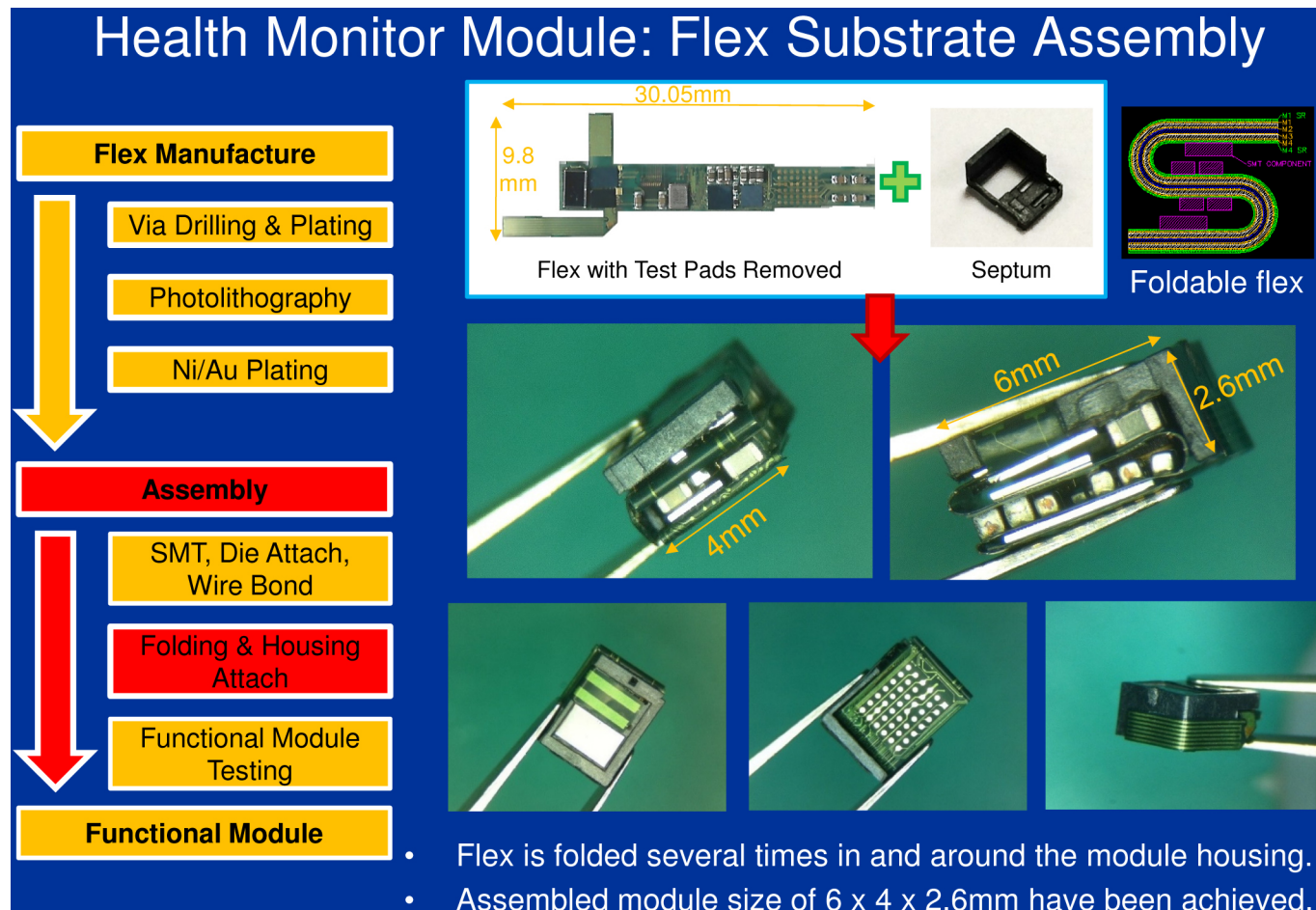
Flexible Electronics.....

- **Glass-based products**
 - More than just Google Glass
 - Transparent conductive film and glass market
\$6.3 billion by 2024 according to IDTechEx
- **Wearable electronics**
 - IDC projects >\$20 billion market in 2018
- **Flex circuit for medical applications**
 - Portable
 - Disposable
 - Wearable

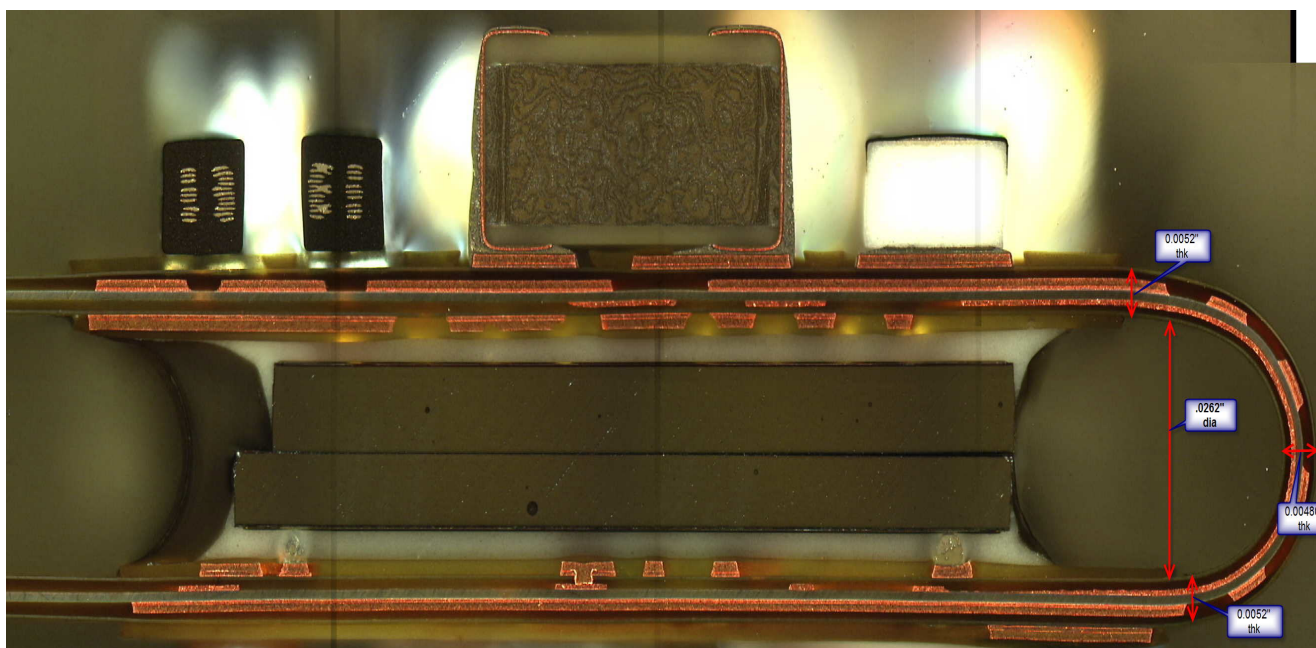
Wearable Electronics Enabled by Flexible Circuits

- **Flexible substrates**
 - **Materials such as polyimides, LCP, Teflon, etc.**
 - **Thin substrates**
 - **Fine pitch features**
 - **Multiple die**
 - **Embedded active die and passives possible**
 - **Folded assembly**
- **Low-cost processing**
 - **Roll-to-roll**
 - **Flexibility**
- **Reliability proven historically**

Example of Flexible Circuit Use for Wearable Medical



Starkey Labs Hearing Aid with Folded Flex

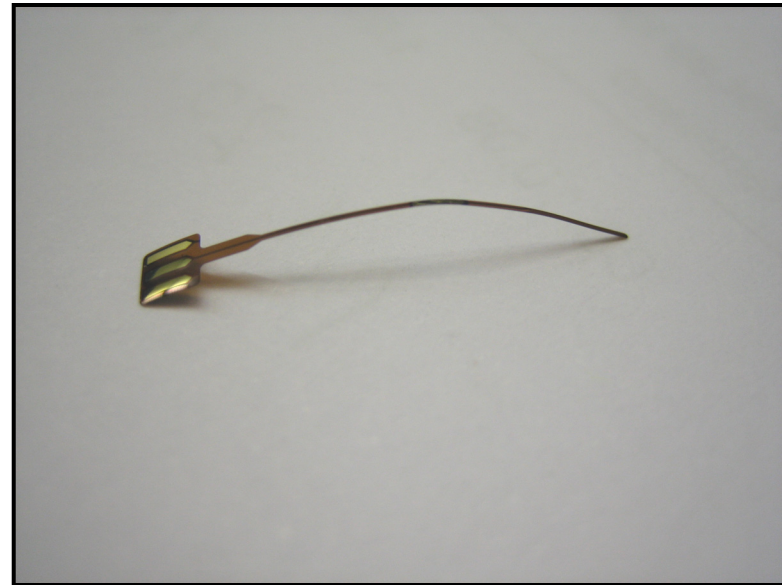
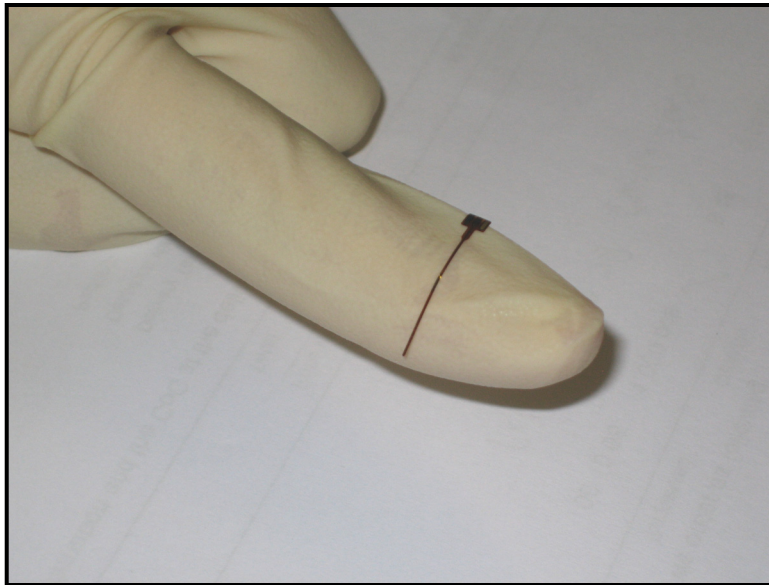


- Typically four-layer flex circuit
- Components assembled with SnPb or Pb-free solder
- May contain flip chip mounted parts, passives down to 0201
- Protected by conformal coating

Source: J. Dzarnoski, Starkey Labs

Blood Sugar Sensor

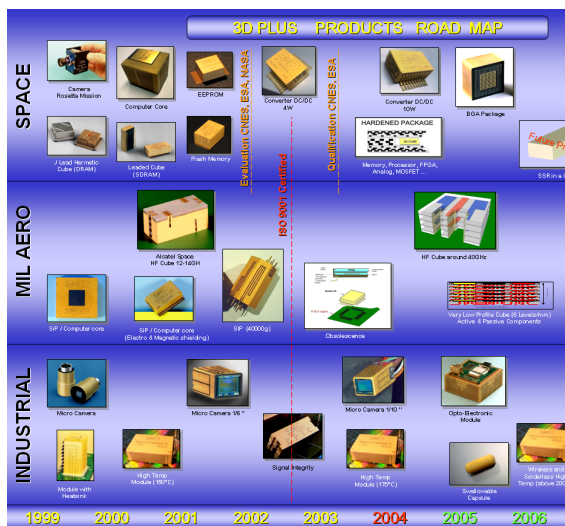
- **Diabetes affects 200 million people worldwide with projections for 366 million people by 2030, 21 million in the United States**
 - **\$132 billion spent on diabetes and its complications**
- **Flex circuit (25 μ m L/S) for blood sugar sensor**



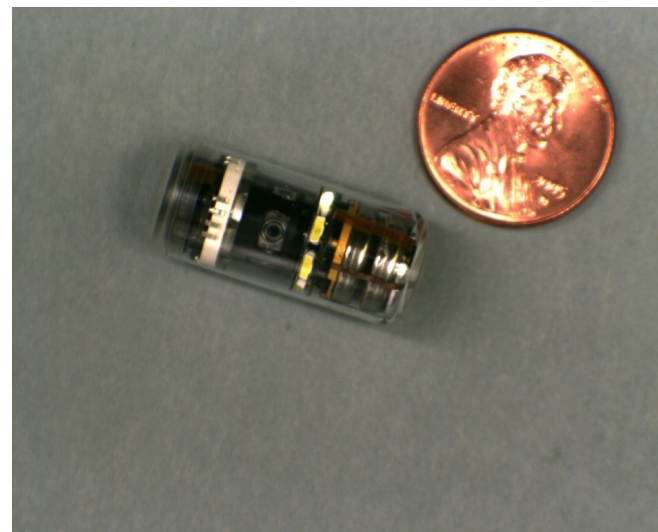
Source: Courtesy of Cicor

Camera Pills

- Camera pills
 - 3D Plus uses flex circuit
 - ADL Engineering in Taiwan uses PoP



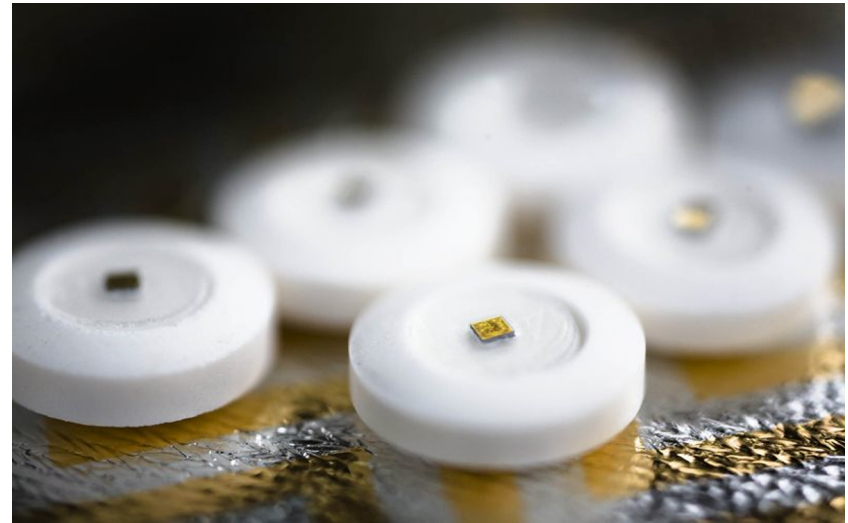
Source: 3D Plus



Source: ADL Engineering

Wearables and Sensors for Medical Electronics

- **Home Health Care**
 - Insulin delivery
 - Monitor heart rate and blood pressure
- **Management of chronic diseases (heart failure, infectious disease, psychiatric disorders)**
 - Digestible sensors (activated by stomach fluids after swallowing)
 - Sends signal to microelectronic receiver under patient's skin storing info on drug, monitors body's response to medication
 - Use mobile phone/internet to provide information to care givers and health care professionals
- **Working with implantable devices**
 - Wireless sensing and communication to manage heart failure and aneurysms



Source: Proteus Biomedial



Making Flexible Electronics a Reality

- **New materials**
- **New low-cost processing**
 - Roll-to-roll
 - Low cost materials
- **New battery technology**