

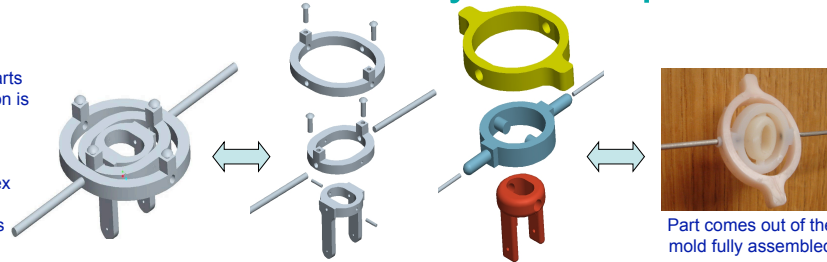
## In-Mold Assembly Concept

### Motivation

- Traditional manufacturing
  - Fabricate individual parts
  - Assemble parts to create products
- Difficulties
  - Complex assembly operations need to be done manually
    - Increases defect rates
    - Significant labor costs
  - Assembling small parts is very challenging

This design contains parts whose largest dimension is less than 2 mm

Small parts and complex geometry make it very difficult to assemble this MAV swashplate



Traditional design created by machining and manual assembly  
Consists of 11 parts and 10 assembly operations

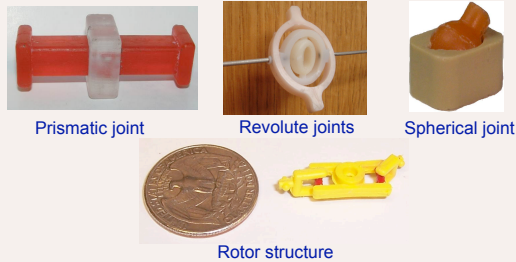
New design enabled by in-mold assembly  
Consists of 5 pieces and no assembly operation

### Goals

- Explore alternative ways to control deformation at the interfaces
- Develop model to estimate deformation of premolded components
- Develop an understanding of in-mold assembly shrinkages
- Develop model to estimate joint clearances
- Develop mold design templates to realize rigid body and compliant joints

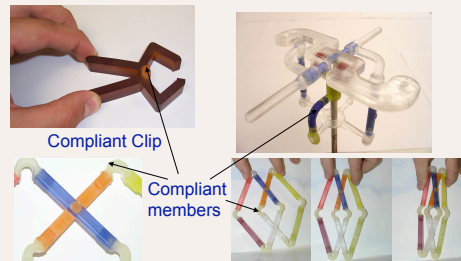
## Process Capabilities

### Rigid Body Joints



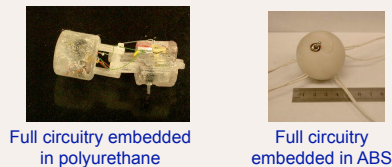
- We have developed mold design templates for successfully realizing revolute, prismatic, spherical, and universal joints using in-mold assembly
- We have developed methods to control shrinkage of the second stage part to provide the adequate joint clearances

### Compliant Joints



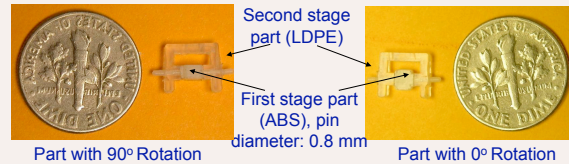
- We have developed mold design templates for realizing variety of 1 DOF and 2 DOF compliant joints using in-mold assembly
- We have characterized the influence of interface geometry on the interface strength to optimize joint performance

### Embedded Electronics



- We used in-mold assembly process to successfully embed batteries and electronics in a snake robot module
- We have shown that embedded electronics exhibits superior resistance to mechanical and thermal impacts

### Mesoscale Joints



- We were the first research group to successfully realize mesoscale revolute joint using in-mold assembly
- We have developed methods to predict and control second stage part deformation due to the melt part interactions

## Applications

### Flapping Wing MAV

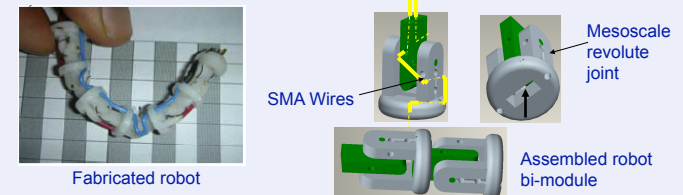


- MAV built at the Manufacturing Automation Lab held a sustained flight and was radio controllable
- Molded drive mechanism converts rotary motor motion to flapping action for wings
- In-mold assembly methods used to
  - Automate assembly process
  - Eliminate fasteners
  - Decrease weight

Attributes of MAV

Overall Weight	12.9g
Flapping frequency	12.1 Hz
Flight Duration	5 min
Flight velocity	4.4 m/s

### Miniature Robot



- Shape memory alloy (SMA) actuated robot developed by Manufacturing Automation Lab in collaboration with RAMS
- In-mold assembly methods used to
  - Significantly reduce part count
  - Eliminate fasteners