

# ESH R&D Opportunities

**SRC Environmental Thrust Mtg**

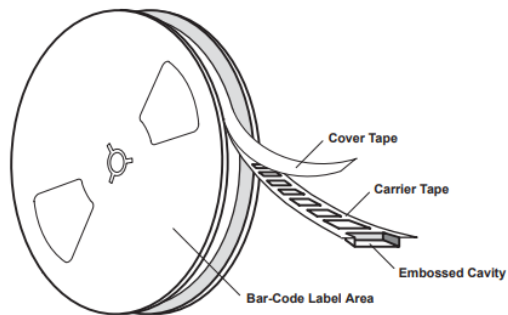
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# Agenda

- Plastics / Shipping materials
  - Our plastics
  - Global regulatory landscape
  - Challenges
  - R&D opportunities
- PFAS
  - Uses in Semiconductor
  - Regulatory landscape
  - PFAS Industry efforts
  - R&D opportunities
- Climate related
  - Etch Gas and HFC chiller loop use
  - R&D opportunities

# Our plastics: Shipping (packing) material



# Shipping materials/plastics: Legislative actions

## European Union (EU)

- “In a ‘circular economy’, waste is reduced and goods are re-used and recycled as much as possible. This means that packaging waste should also be reduced, and packaging should be made easier to recycle.”
- Packaging directive consultation in 2020 – waiting report and amendments

## India

- Plastics import permit / licensing and recycled content goals / requirements apply to producers, importers, and brand-owners (EPR - extended producer responsibility).
- Entities are mandated to meet specific targets based on the volume and the category of plastic waste generated
- Customs will provide the enforcement

# Shipping materials/plastics: Legislative actions

## Philippines

- Requirements in motion:

| Philippines regulatory timeline   | When                    |
|---|-------------------------|
| Drafting of EPR IRR and focus group discussions with stakeholders           | Sept. 1-30, 2022        |
| Finalization of draft IRR   | Oct. 1 -15, 2022        |
| Executive Committee review of EPR IRR                                       | Oct. 16 – Nov. 14, 2022 |
| Draft IRR will be provided to the Senate Committee Chair                    | Nov. 15, 2022           |
| Enterprises required to phase-in the EPR program in their plastic packaging | Feb. 23, 2023           |
| Enterprises required to submit annual waste recovery targets                | Oct. 23, 2023 onwards   |

## United States

- Themes: single use plastics, EPR, recycle, reduction
  - State provisions ~50 in play this year
  - Federal ~4 active – Carper S3734 passed the Senate – in EPW

# Shipping materials: challenges

## Legislative themes

- Reporting volumes and recycled content
- Elimination of some substances
- Goals or targets increasing recycled content and reducing volumes
- Goals linked to customs controls, fees and permits

## Our challenges

- No coordinated effort to modify existing materials
  - Market factors and standards are needed
- Our shipping materials have specific quality and performance requirements
  - Destructive contamination from out gassing
  - Physical performance across the sector (In parts placement equipment)

# Shipping material R&D opportunities

## Recycled Materials

- Increasing recycled content without increasing quality risk

## Alternative materials

- Bio-based materials

## Quality determinations

- Test parameters

Research specifics – Survey of industry and member company standards to determine quality parameters necessary to ensure proper performance that would include outgassing criteria and analytics.

# Pefluoro Alkyl Substances (PFAS)



# PFAS: Critical for semiconductor manufacturing

## In factories

- Fluoropolymers in the facility and tools
- Fluorinated Heat transfer fluids – specialty fluids for equipment chillers >100/fab
- Thin films and etch gases in fabs
- Lithography chemistry
- Specialized equipment lubricants
- Potentially some surfactant uses in fab chemicals

## In products

- Some potentially affected products

# PFAS: Regulatory landscape

## EU

- REACH Restriction – All PFAS
- Proposal due Jan. 1, 2023
- Heavy bias against exemptions
- Expected to be in effect in 2025 or 2026
- Output expected to feed the UN Persistent Organic Pollutants (POP's) treaty process

## United Nations (UN)

- PFOS and PFOA are listed in the POP's treaty
- Long Chain Perfluoro Acids are starting in the process – expect effective in 2027 or later
- Sort chain PFASs will enter the UN process after the REACH Restriction is published

# PFAS: Legislative actions

## U.S.

### *Federal*

- EPA timeline established to use existing framework for CERCLA(superfund), RCRA (hazardous waste), CWA (water), CAA(Air), TSCA (chemical use)
- Over the next 10+ years
- Includes articles or finished products that contain PFAS

### *State*

#### **Maine**

- Law passed to require communication of all PFAS uses by 1/1/23
- Those not communicated cannot be sold in Maine after 2030
- Implementing regulation on reporting is currently being written but draft indicates broad application without thresholds or exemption

#### **New Jersey**

- Similar to Maine – faster implementation - 2025

Other states are working on similar requirements to label, communicate or restrict PFAS use

# PFAS: Industry efforts

## PFAS Consortia

- Beginning in 2022 thirty five company's have agreed to collaborate to identify uses, determine if alternatives exist and document the rationale for use
- Includes device manufacturers and suppliers of PFAS molecule manufacturers, specialty chemical blenders, equipment and polymers.
  - Covers fab, Bump and A/T uses
- Prepare technical details to inform industry, research and regulators
- Output
  - Papers and reports to use with regulators
    - Socioeconomic reports – expected YE 2023
    - Alternatives development – 2023 and later
    - Controls needed – 2023 and later
    - Analytics – likely on-going for several years

# PFAS R&D opportunities

- Analytics
  - Refined methods for measuring PFAS/fluorinated organics on shipped wafers and modules.
  - Improvements/validation of TOF measurements in wastewater and wastes;
  - Improvements in the analytical methods needed to close the gap between TOF and the # PFAS that are individually measurable with existing methods.
  - Continuing and improved characterization of the fluorinated organics likely produced during plasma and SPM resist strip.
  - PFAS in ambient air and air emissions
- Non-fluorinated (and low ESH impacting) alternatives
  - Heat Transfer Fluids, Etch Gases, Lubricants, Adhesives, Polymers and Surfactants
- Controls
  - Improved air and wastewater emission controls – near zero release

R&D funding  
for analytics,  
alternatives  
and controls  
(US and EU  
Chips Act)



# Kigali/Montreal Protocol

# Climate related – Kigali/Montreal Protocol

- Kigali implementation – HFC's\* (F-Gas\*\* EU issue)
  - Applies to all HFC gases – production phase down to limit supply
  - Most governments are implementing requirements of the agreement
  - Ratified in the US with process chemical allowances for device manufacturers
  - Each Party to the treaty is required to implement control conditions
  - Not all countries are implementing the same way
    - Some do not provide for semiconductor specialty etch gas uses – small volumes
    - Not aware of any specialty Fluorinated Heat Transfer Fluid allowances

\*HFC - Hydrofluorocarbons \*\*F-Gas - Fluorinated Gas regulations

# Climate related – Kigali/Montreal Protocol

- Device manufacturer uses
  - Specialized etch gases (Fab) -  $\text{CH}_3\text{F}$ ,  $\text{CH}_2\text{F}_2$ , and  $\text{CHF}_3$ 
    - Low volume – no identified replacements
    - Specific etch processes
  - Specialized HFC heat transfer fluids
    - Required to offload heat from Fab plasma processing equipment
    - >100 point of use chillers / fab
    - Properties
      - » High thermal stability
      - » Broad range of operating temperatures
      - » Good dielectric properties
      - » Chemically inert
      - » Compatible with metals, plastics and elastomers
      - » No flash, fire or auto-ignition points
      - » Safety (FM approved 6930)
      - » NSF approved



Source: [USEPA](#) -- USES AND EMISSIONS OF LIQUID PFC HEAT TRANSFER FLUIDS FROM THE ELECTRONICS SECTOR



# Climate related – Kigali/Montreal Protocol

- R&D opportunities
  - Alternative etch gases to replace  $\text{CH}_3\text{F}$ ,  $\text{CH}_2\text{F}_2$ , and  $\text{CHF}_3$
  - Non-fluorinated specialty heat transfer fluids
- Barriers to overcome
  - Huge investment in existing installed base globally (456 listed in Wikipedia)
  - New factory designs required if the liquid or gas has characteristics requiring safety controls
    - » corrosive,
    - » acutely toxic,
    - » flammable
  - Bottom line: Needs to work in existing systems
    - » Or designed into a new factory

**Thank you!**