Substitution of Over-engineered Barrier Packaging Films Using HDPE Barrier Film Lamination Technology

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Agenda

- High-Barrier Food Packaging Background
- HDPE Barrier Lamination Concept
- Comparison of HDPE Barrier Laminations with Existing Food Packaging Structures
- Summary and Conclusions

Introduction

- Historically, packaging requiring excellent barrier properties has used foil
- Package development for improved performance and lower costs led many barrier food packaging applications to move to metalized film
- Alternatively, consumer packaged good companies may want to show their product via windows in the package
  - To meet barrier requirements, these structures typically use ethylene-vinyl alcohol (EVOH) or nylon
- New developments in HDPE resin design and nucleation allow the manufacture of films with significantly improved moisture barrier over traditional HDPE resins used in barrier applications
- Use of next-generation HDPE barrier products may contribute to films with sufficient product shelf life for over-engineered packages

High-Barrier Food Packaging

- A major market for barrier film (metalized or non-metalized) is stand-up pouches
- 2013 United States pouch usage = 17 billion units
  - 50% growth in past five years
- Food applications represent over 60% of pouch end-uses
  - Pet food = 33%; Human food = 30%
- Forecasted 2018 US pouch demand = 24 billion units
- Growth spurred by bottle/can replacement, packaging cost reduction, and increased consumer convenience

Pouches offer significant current and future market opportunity

Source: Packaging Digest, October 31, 2013.

Typical High-Barrier Packaging Structures

Reverse-printed PET/oPP Film
LDPE Laminating Layer/Adhesive
Metalized PET/oPP Film
LDPE Laminating Layer/Adhesive
PE Sealant Film

Reverse-printed PET/oPP Film
LDPE Laminating Layer/Adhesive
Multi-layer Film PE Skin Tie-Layer EVOH or Nylon Tie-Layer PE Sealant Film

- Typical overall structure gauge = 3.0 – 5.0 mil
- Metalized structures require two passes through lamination line
- EVOH/Nylon films require at least a 5-layer film line
- Applications – Bags/pouches for end-uses typically requiring good moisture and/or oxygen barrier

HDPE Barrier Lamination Structures

Reverse-printed PET/oPP Film

LDPE Laminating Layer

HDPE Laminating Film

Use same base substrate and LDPE laminating layer as current metalized film or EVOH structures

- HDPE Laminating Films are blown films having excellent moisture barrier made with next-generation HDPE resins
  - Replaces metalized films and sealant layers
- These films may use co-extrusion technology to incorporate other materials for other packaging features
  - O_2 barrier, sealant, toughness, etc.

Potential Advantages for HDPE Barrier Lamination

- Lower costs
  - Material costs
  - Single-pass through extrusion coating line
- Food packaging differentiation
  - Windows (if desired) to view product
- Improved food product safety
  - Allow use of metal detectors for metal contaminants
  - Allow use of high voltage leak detection systems
- Ability to tailor film structure to enhance package
  - Use different polymers/layers for barrier (H_2O, O_2), toughness, sealing/opening, etc. as desired
- Overall structure yield advantage by eliminating metalized PET film

HDPE Barrier Lamination Sample Preparation

- Produced 3-Layer (ABA) co-ex blown films
  - Skin layers (A) were butene LLDPE
    - Primary functions were toughness and a sealant layer
  - Core layer (B) was nucleated, next-generation HDPE homopolymer
  - Used layer distributions of 15-70-15 and 30-40-30
  - 3.0-mil total gauge

- Produced extrusion lamination structures
  - Used 48-gauge PET film as substrate
  - Laminated ABA co-ex films to PET with 0.5-mil LDPE
  - For subsequent charts:
    15-70-15 = 48-gauge PET / 0.5-mil LDPE / 15-70-15 LLDPE-HDPE-LLDPE
    30-40-30 = 48-gauge PET / 0.5-mil LDPE / 30-40-30 LLDPE-HDPE-LLDPE

- Total gauge of laminated structure = 4.0 mil

Blown Film Line Conditions: 6-inch die, 60-mil die gap, 3.0:1 BUR
Extrusion Coating Line Conditions: 7-inch air gap, 615^{o}F melt temperature, 250 feet per minute line speed, Michelman MFP888 primer

HDPE Barrier Lamination Comparison Testing Structure #1

- Purchased cookies packaged in metalized film
- Analytical testing found packaging was 3-ply with:

Reverse printed PET primary substrate
Adhesive Lamination
Metalized PET film layer
Adhesive Lamination
PE-based sealant layer

- Total film gauge = 3.4 mil
- Test samples cut from packages for film testing
  - Toughness – Tear, Puncture
  - Stiffness
  - Optics
  - Food aging

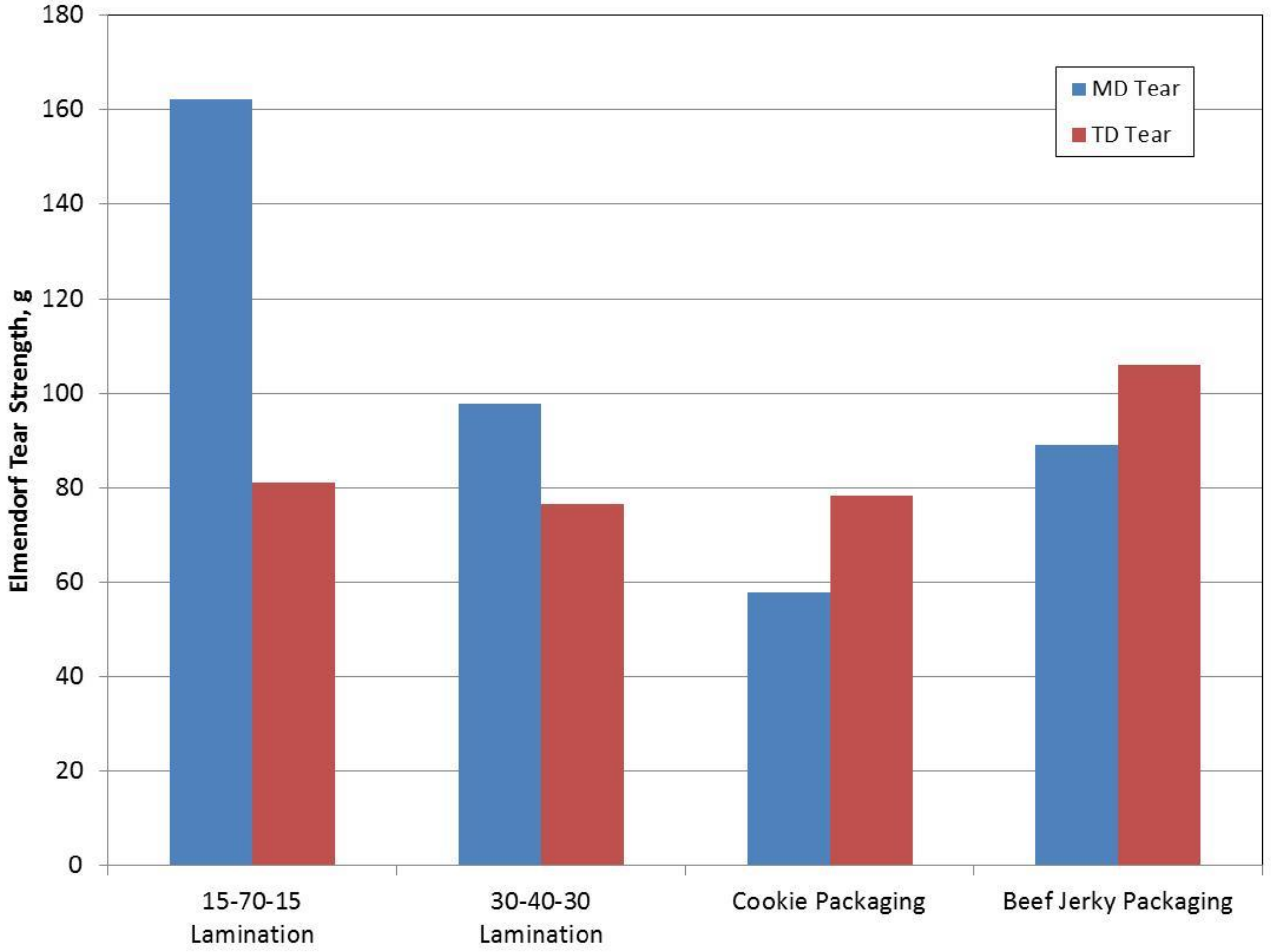
HDPE Barrier Lamination Comparison Testing Structure #2

- Purchased beef jerky packaged in non-metalized structure, but known to require good barrier
- Analytical testing found film was 2-ply with:

Reverse printed PET primary substrate
Adhesive Lamination
4.5-mil LLDPE-tie-EVOH-tie-LLDPE co-ex film

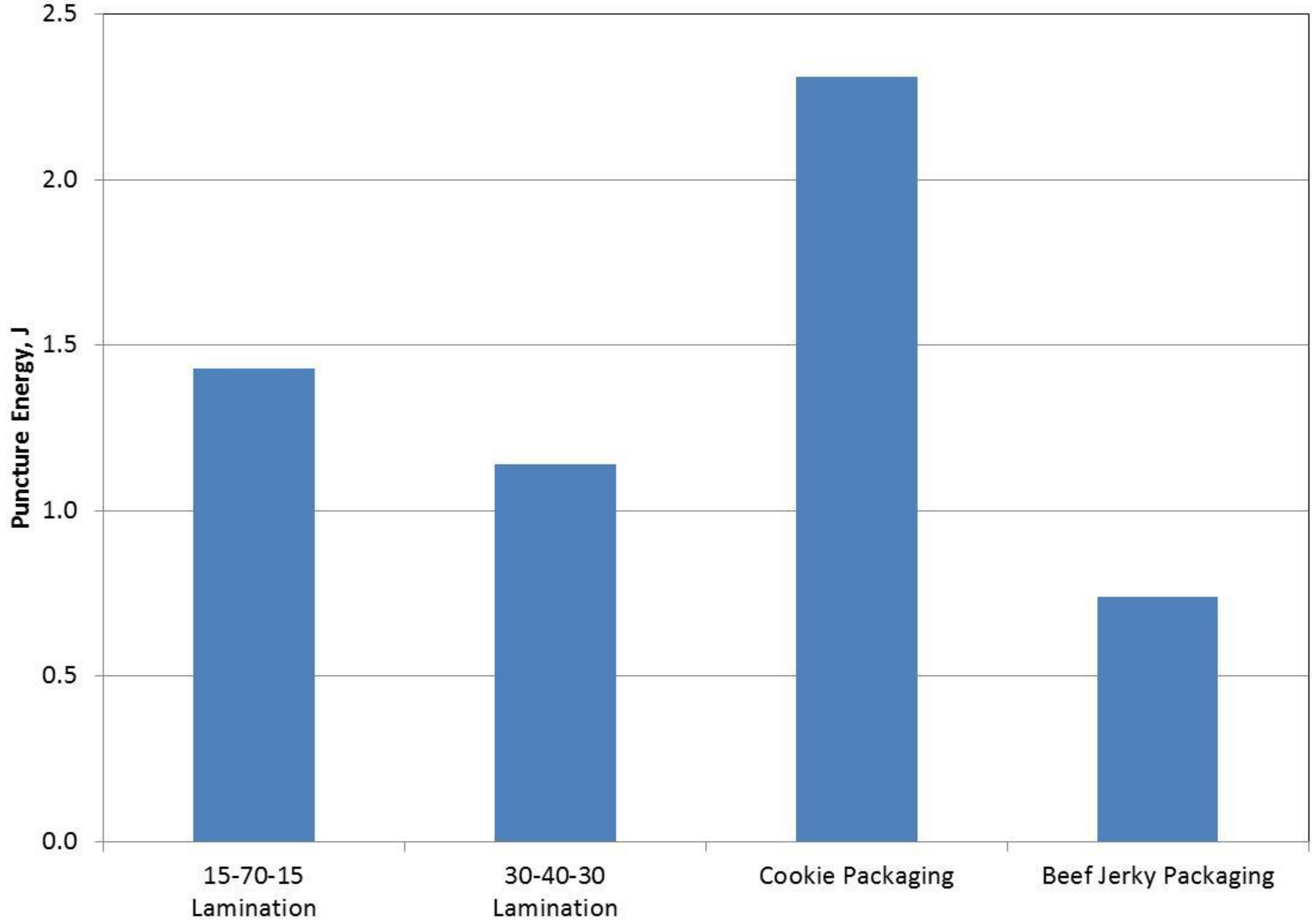
- Total film gauge = 5.0 mil
- Similar film testing completed as metalized film samples

HDPE Barrier Lamination Comparison Testing Tear



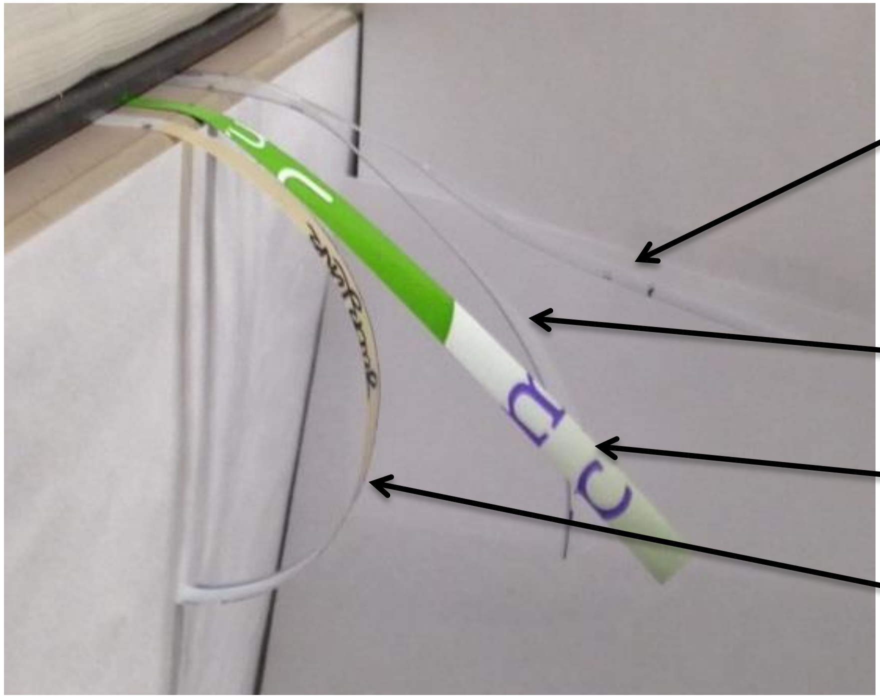
Barrier Lamination structures have as good or better tear

HDPE Barrier Lamination Comparison Testing Puncture



Barrier Lamination structures have better puncture than beef jerky packaging

HDPE Barrier Lamination Comparison Testing
Stiffness



- Stiffness measurements are difficult for films
- To try to compare stiffness, 0.5 mm by 100 mm strips cut from packages
- Specimens allowed to overhang table (10 mm held on table)

Barrier Lamination structures appear to have higher stiffness

HDPE Barrier Lamination Comparison Testing Optics

Dog Treat | Beef Jerky

15-70-15 Lamination
(Haze = 31)

30-40-30 Lamination
(Haze = 22)

Current Package

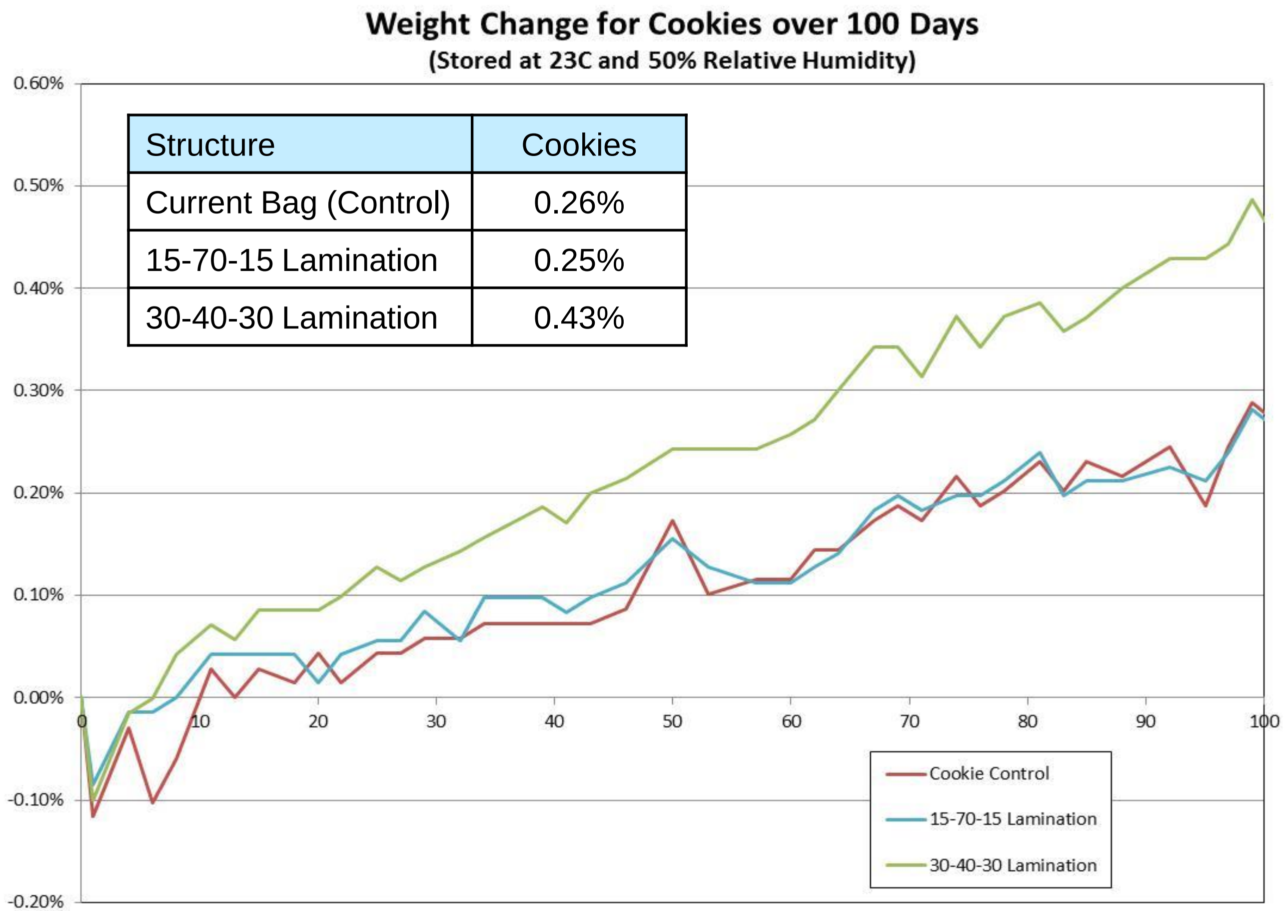
Barrier Lamination structures allow product to be seen (if desired)

Current Beef Jerky package haze = 33

HDPE Barrier Lamination Comparison Testing
Food Aging

- To assess potential real-world shelf-life performance, completed food-aging studies by making simulated packages
- Cut 4-inch by 4-inch sections of film
  - Produced control samples using metalized film structures
- Heat sealed film edges to fusion
- Filled package with food samples
  - Approximately 20 grams of cookies and beef jerky
  - 3 specimens per sample
- Stored samples in 23^{o}C, 50% relative humidity lab
- Weighed samples on Monday, Wednesday, and Friday

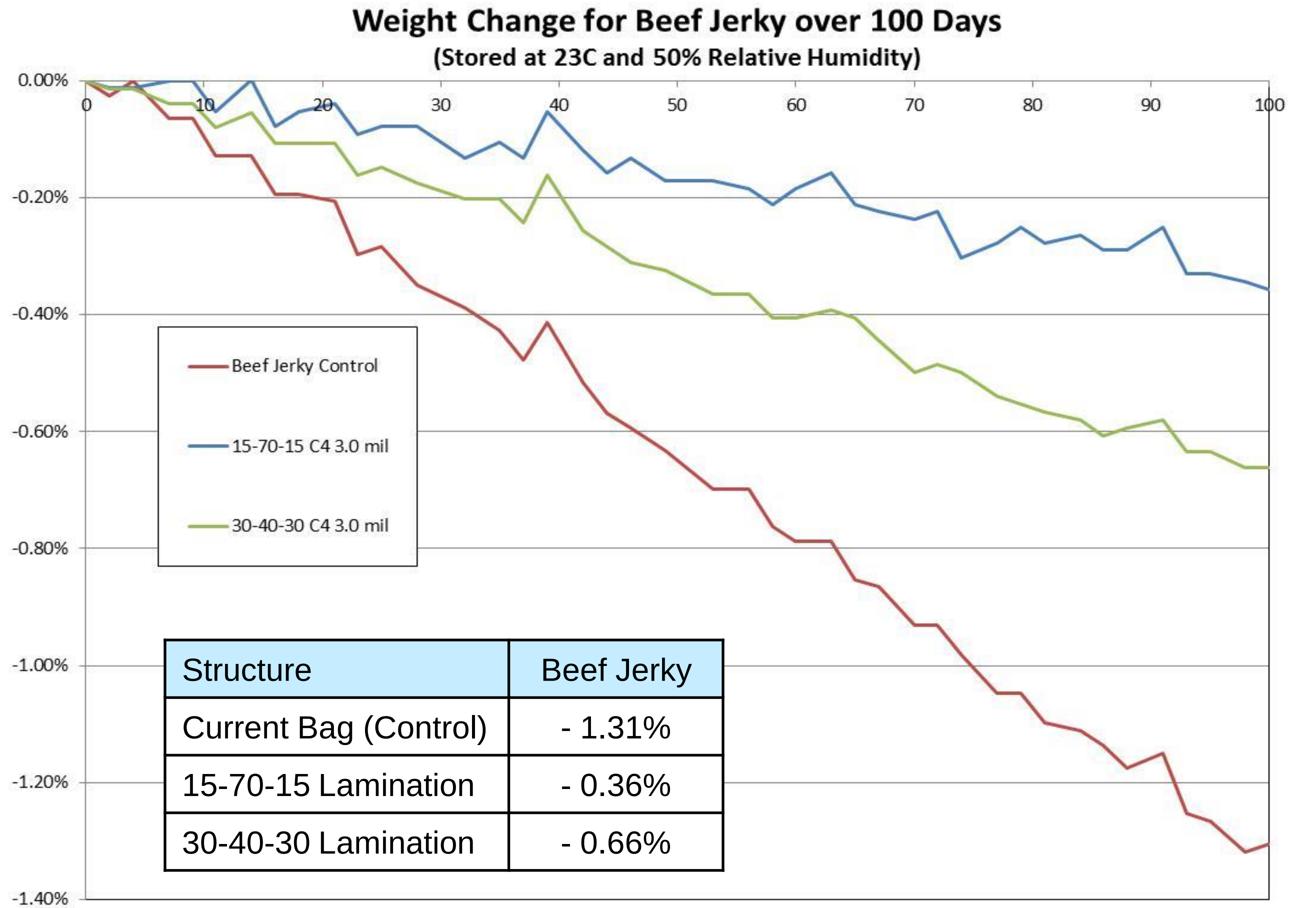
HDPE Barrier Lamination Comparison Testing
Food Aging - Cookies



Structure	Cookies
Current Bag (Control)	0.26%
15-70-15 Lamination	0.25%
30-40-30 Lamination	0.43%

Higher HDPE content leads to structures with similar weight change to the control bag, which may be sufficient for some applications

HDPE Barrier Lamination Comparison Testing
Food Aging – Beef Jerky



Structure	Beef Jerky
Current Bag (Control)	- 1.31%
15-70-15 Lamination	- 0.36%
30-40-30 Lamination	- 0.66%

Barrier lamination structures appear to show significantly less weight change over time than current package

Results Summary

+ indicates improved performance for lamination
- indicates better performance by existing structure

15-70-15 Lamination	Cookie	Beef Jerky
Tear	++	+ (MD) / - (TD)
Puncture	-	++
Stiffness	++	++
Haze	+++	=
Food Aging	=	++

30-40-30 Lamination	Cookie	Beef Jerky
Tear	+	= (MD) / - (TD)
Puncture	-	++
Stiffness	++	+
Haze	+++	+
Food Aging	-	+

While food aging may not be equivalent, is it sufficient for over-engineered packages based on the product’s shelf-life requirements?

Summary and Conclusions

- New barrier lamination structures may be closing food freshness gap
- Over-engineered packages may be able to move to polyolefin-based lamination film structures
- New non-metalized structures may offer other benefits
- Additional structure and material optimization may lead to even further improvements in performance and costs

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