DENTAL MATERIALS
High Tech Advances and New Materials

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http://www.dent.unc.edu/portfolios/bayne/dental-materials/

A. Staying UP-TO-DATE
B. Dental Materials TECHNOLOGIES
   > Advanced composites
   > Dentin bonding systems
   > Light-curing technologies
   > Sonic and ultrasonic cleaning devices
   > Lasers for cutting tooth structure
   > Advanced CAD/CAM
   > Procera crowns
   > Air-abrasion equipment
   > Amalgam / Hg recovery equipment
   > Computerized color analysis
   > Electronic caries detectors
C. Office TECHNOLOGIES
   > Wearable computers
   > Wireless office networks

COMPOSITE REFINEMENTS

1990 2000 2010

The next generation.

Dental amalgam
Dental composite
Glass ionomer, A.R.T.
Bonding systems
Dental cements
Ceramic restorations
CAD/CAM technology
Esthetic procedures
Computers

OVERVIEW

http://www.net32.com/
Pat Cassidy, D.D.S.
Durham, NC

http://www.net32.com/
**CURRENT COMPOSITES**

- **HYBRIDS (or MIDI-HYBRIDS):**
  - Filtek Z250 and Z100 (3M)
  - Prisma APH and TPHTP (Dentsply)
  - Tetric Spectrum (Dentsply)
  - Herculite XRV and Prodigy (Kerr)
  - Ecusit Composite (DMG Hamburg)
  - Tetric Ceram (Ivoclar/Vivadent)
  - BisFil II and 2B (BISCO)
  - Synergy (Coltene-Whaledent)
  - Marathon (Denmat)
  - Clearfil AP-X (Morita)
  - Clearfil X110 = Silux Plus (3M)

- **MINI-HYBRIDS (MICRO-HYBRIDS):**
  - Esthet-X (Dentsply)
  - Point 4 (Kerr)
  - Vitacell (Ivoclar/Vivadent)
  - Renew (BISCO)
  - BisFil II and 2B (BISCO)
  - Synergy (Coltene-Whaledent)
  - Marathon (Denmat)
  - Clearfil AP-X (Morita)
  - MicroNew (BISCO)
  - Perfection (Biscofix)
  - Filtek A110 = Silux Plus (3M)
  - Amelogen (Ultradent)
  - Virtuoso Sculptable (Denmat)

- **FLOWABLES:**
  - Esthet-X (Dentsply)
  - Point 4 (Kerr)
  - Venus (Hereaus-Kulzer)
  - Vitacell (Ivoclar/Vivadent)
  - Ultradent

- **PACKABLES:**
  - Superlux (DMG Hamburg)
  - Heliomolar (Ivoclar/Vivadent)
  - MicroNew (BISCO)
  - Perfection (Biscofix)
  - Filtek A110 = Silux Plus (3M)
  - Amelogen (Ultradent)

- **MICROFILLS:**
  - Superlux (DMG Hamburg)
  - Heliomolar (Ivoclar/Vivadent)
  - MicroNew (BISCO)
  - Perfection (Biscofix)
  - Filtek A110 = Silux Plus (3M)
  - Amelogen (Ultradent)

- **NANO-HYBRIDS:**
  - Supreme (3M-ESPE)
  - Simile (Pentron)

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**COMPOSITE WEAR**

- **5 Wear Types:**
  - **CFA** = food bolus wear
  - **OCA** = impact wear
  - **FCA** = sliding wear
  - **PCA** = sliding wear
  - **TBA** = abrasive wear

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**AFM OF SURFACES**

- **Rough Finished**
- **Fine Finished**

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**FILLER PRODUCTION**

- **BULK FILLER PRODUCTION:**
  - Melting or vitrification.
  - Cooled to solid.
  - Ground and sifted.
  - Reground and sifted.
  - Key particle size is collected.

- **GAS PHASE PRECIPITATION:**
  - Pyrolysis of reactants.
  - Gas phase formation.
  - Precipitation.
  - Cooling.

- **SOL-GEL FORMATION:**
  - Solution reaction.
  - Formation of tiny ceramic domains.
  - Domains may be single or clustered.
  - Gel dried and powdered.

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**Wilder AD, May KN, Bayne SC, Taylor DF, Leinfelder KF.**

DECEPTIVE NAMES
Nanocomposites = constituents mixed at a nano-length scale.

NANOCOMPOSITES

FILTEK SUPREME (3M-ESPE)
78.5 w/o filler loading
Nano-cluster size is 0.6-to-1.4 µm
Called a micro- or nano-hybrid?

SIMILE (Pentron)
Relatively high filler loading
Silicate cage size is 5-20 nm
Called a micro- or nano-hybrid?

The “WAR” of the
POWERED TOOTHBRUSHES

BIOFILM EFFECTS
SEM surface of biopsied 10-year old posterior composite.
FIRST GENERATION FLOWABLES

- Filtek Flow (3M-ESPE)
- MetaFil Flo (Sun Dental)
- Revolution F2 (Kerr)
- Versaflo (Centrix)
- Ultraseal XT+ (Ultradent)
- True Look (Denpac/5 Star)
- Star Flow (Danville Eng.)
- FloRestore (DanMat)
- Crystalessence (Confidental)
- Aelite Flo LV (BISCO)
- Revolution (Kerr)
- Flo-It (Jeneric/Pentron)
- FloRestore (DenMat)
- Crystalessence (Confidental)
- Aelite Flo (BISCO)
- Revolution (Kerr)
- Flo-It (Jeneric/Pentron)

SECOND GENERATION FLOWABLES

- UniFil Flow (GC America)
- Virtuoso Flow (DenMat)
- Revolution Formula 2 (Kerr)
- Flow-It-ALCALC (Pentron)
- Aria (Danville Eng.)
- PermaFlo (Ultradent)
- LuxaFlow (DMG)
- Aelite Flo LV (BISCO)
- Point 4 Flowable (Kerr)
- Wave (SDI)
- Heliomolar Flow (Ivoclar/Vivadent)
- Filtek Flow (3M)

FLOWABLE COMPOSITES

**Definition:** lower viscosity dental composite, generally with lowered filler content.

**First Generation Flowable:**
- Filtek Crystal
- Filtek Crystal Flo
- Flow It
- Revolution
- True Look
- Ultrasol XT+
- Versaflow

**Second Generation Flowables:**
- SureFil
- Synergy Compact
- Filtek P60
- Synergy Compact (Coltene/Whaledent)
- Heliomolar HB (Ivoclar-Vivadent)
- Hi-Dense Condensable GI (Shofu)
- Fuji IX Packable (GC-America)

FLOW versus WETTING

<table>
<thead>
<tr>
<th>Flowable (Company)</th>
<th>Flow (mm2)</th>
<th># BNT</th>
<th># DNP</th>
<th># SP</th>
<th># FLP</th>
<th># Clin</th>
<th># Byar</th>
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</thead>
<tbody>
<tr>
<td>Flow (N2)</td>
<td>100 ± 10</td>
<td>30</td>
<td>37</td>
<td>55</td>
<td>52</td>
<td>52</td>
<td>62</td>
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<tr>
<td>Flow (N2)</td>
<td>100 ± 10</td>
<td>30</td>
<td>37</td>
<td>55</td>
<td>52</td>
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<td>100 ± 10</td>
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<td>62</td>
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**L.D. CAULK SUREFIL PACKABLE COMPOSITE**

<table>
<thead>
<tr>
<th>Clinical Performance Categories (% elfa):</th>
<th>BL</th>
<th>6m</th>
<th>fy</th>
<th>2y</th>
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<td>Color stability</td>
<td>100</td>
<td>98</td>
<td>98</td>
<td>87</td>
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<tr>
<td>Resistance to marginal discoloration</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>100</td>
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<tr>
<td>Marginal adaptation</td>
<td>100</td>
<td>97</td>
<td>95</td>
<td>94</td>
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<tr>
<td>Surface texture</td>
<td>100</td>
<td>100</td>
<td>98</td>
<td>94</td>
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<tr>
<td>Maintenance of proximal contact</td>
<td>97</td>
<td>97</td>
<td>96</td>
<td>98</td>
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<tr>
<td>Functional occlusion</td>
<td>93</td>
<td>98</td>
<td>95</td>
<td>100</td>
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<tr>
<td>Axial contour</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Resistance to postoperative sensitivity</td>
<td>100</td>
<td>100</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td>Restoration retention</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Resistance to restoration fracture</td>
<td>100</td>
<td>100</td>
<td>98</td>
<td>93</td>
</tr>
<tr>
<td>TOTAL FAILURES</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>4%</td>
</tr>
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</table>
**NEW COMPOSITE GENERATION**

= Low-Shrinkage or Controlled-Shrinkage Composites

**SHRINKING Monomers:**

**EXPANDING Monomers:**

**DOXADENT**

Condensable Direct Ceramic

Doxa Doxadent

http://www.doxa.se/eng/

**DOXADENT**

Mechanical Properties

**BONDED COMPOSITE**

Challenges

**US Companies**

1 = ETCHANT
2 = PRIMER
3 = BONDING AGENT

**Japanese Companies**

1 = ETCHANT
2 = PRIMER
3 = BONDING AGENT

= 1
= 2
= 3

**ETCHANT **

**PRIMER **

**BONDING AGENT **

???
NEWER BONDING AGENTS

1-COMPONENT SYSTEMS (EPB)
- AQBond (Sun Medical) or Touch-and-Bond (Parkell)
- Solist (One-bottle-bond) (DMG Hamburg)
- Bonds (Hereaus-Kulzer)
- Xeno III (Dentsply)

2-COMPONENT SYSTEMS (EP + B)
- Clearfil SE Bond & LinerBond 2v (Kuraray)
- Tyrian SPE (Bisco)
- Optibond Solo SE Plus (Kerr)
- UniP Bond (GC)
- Max Bond II (Tokuyama)
- Nanobond (Pentron)

2-COMPONENT SYSTEMS (E + PB)
- Single-Bond (3M)
- Optibond Solo and Solo Plus (Kerr)
- One-Step (BISCO)
- Excite (Ivoclar/Vivadent)
- OBB Bonding System (ESPE)

3-COMPONENT SYSTEMS (E+P+B)
- Scotchbond Multipurpose Plus (3M)
- Permaquick (Ultradent)
- Bond-It (Jeneric / Pentron)
- All-Bond 2 (BISCO)
- Tenure A/B/S (Denmat)
- ProBond (Dentsply)

3-STEP
Scotchbond Multipurpose Plus
3M Dental Products Division
(Ethanol and water solvent system)

2-STEP
Prime&Bond
Dentsply International
(Acetone solvent system)

2-STEP
Single Bond
3M Dental Products Division
(Ethanol and water solvent system)

1-STEP
Prompt L-Pop
3M ESPE Dental Products
(Ethanol and water solvent system)
**CURING LIGHT TYPES**

- **Quartz Tungsten Halogen (QTH) Lights**
  - Continuous output – normal intensity
  - Continuous output – high intensity
  - Staged output (stepped, ramped, …)

- **Plasma Arc Curing (PAC) Lights**

- **Argon Laser Curing (Laser) Lights**

- **Light Emitting Diode (LED) Lights**

**FACTORS AFFECTING CURE**

- **Curing Equipment Factors**
  - Bulb frosting or degradation
  - Light reflector degradation
  - Optical filter degradation
  - Fiber-optic bundle breakage
  - Light-guide fracture
  - Tip contamination by resin buildup
  - Line voltage inconsistencies
  - Sterilization problems
  - Infection control barriers

- **Procedural Factors**
  - Light tip direction
  - Access to restoration
  - DISTANCE from surface
  - Size of tip
  - Tip movement
  - TIME of exposure

- **Restoration Factors**
  - Restoration thickness
  - Cavity design
  - Filler – amount and size
  - Restoration shade
  - Monomer ratios

**LED LIGHTS**

**Light Emitting Diodes**

- **Advantages:**
  - Matched to CQ peak.
  - Reduced "I" needed.
  - Easy to clean.
  - Totally quiet; No fan.
  - Small; Handy.
  - No wires.

- **Elipar FREELIGHT 1**

**LED LIGHTS in the WORLD**
**LED CURING LIGHTS**

<table>
<thead>
<tr>
<th>VLC LED Name</th>
<th>Company</th>
<th>Price</th>
<th>LEDs</th>
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</thead>
<tbody>
<tr>
<td>Elipar FreeLight</td>
<td>3M ESPE</td>
<td>$999</td>
<td>19</td>
</tr>
<tr>
<td>NRG</td>
<td>Dentsply/Caulk</td>
<td>$949</td>
<td>7</td>
</tr>
<tr>
<td>Ultra Lume LED 1</td>
<td>Ultradent</td>
<td>$999</td>
<td>12</td>
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<tr>
<td>Ultra Lume LED 2</td>
<td>Ultradent</td>
<td>$1299</td>
<td>12</td>
</tr>
<tr>
<td>CoolBlue</td>
<td>Dental Systems</td>
<td>$1195</td>
<td>7</td>
</tr>
<tr>
<td>Nova</td>
<td>Curing Technologies</td>
<td>$1495</td>
<td>7</td>
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<tr>
<td>GC e-Light</td>
<td>GC America</td>
<td>$1495</td>
<td>7</td>
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<tr>
<td>Allegro</td>
<td>Denmat</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Elipar FreeLight 2</td>
<td>3M ESPE</td>
<td>$1495</td>
<td>1</td>
</tr>
<tr>
<td>LEDemelon</td>
<td>Kerr</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ultra Lume LED 5</td>
<td>Ultradent</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

**A.R.T. TECHNIQUE**

(Atraumatic Restorative Technique)

Developed as temporary restorations for 3rd world countries. First tested in African countries. Now used widely in Asian countries.

Original technique = scoop, finger mix, finger insertion. Current technique = P/L or precapsulated mixture.

Now being used as permanent restoration in pedodontics.

**Best Management Practices**

[Use alternatives / Keep products separate / Recycle everything]

1. Dental Amalgam
   (a) Spent Amalgam Capsules
   (b) "Non-Contact" Amalgam (left-over from mixing procedures)
   (c) Chair-side Traps ("Contact-amalgam" trapped by coarse filter)
   (d) Vacuum Pump Filter ("Contact-amalgam" trapped by medium filter)
   (e) Separator or Recapature Device (added before vacuum with fine filter)
   (f) Plumbing and Sink Traps
   (g) Hg Spill Kits

2. X-ray Wastes
   (a) Fixer (Ag recovery or recycling processes)
   (b) Developer (controlled discharge into sanitary sewer)
   (c) Cleaners (C-containing cleaners must be recycled)
   (d) Lead foil (must be recycled)
   (e) Lead Shields (e.g., aprons) (must be recycled)

3. Chemical Sterilant Wastes
   (a) Chemiclave/Chemical-Sterilant (dilute 4:1 with water before draining)

4. Waste Waters
5. Fluorescent Lamps and Batteries (recycle only)

**OVERVIEW**

<table>
<thead>
<tr>
<th>Year</th>
<th>Dental Amalgam Use in the United States</th>
<th>EPA OSHA FDA NAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>1000 patients</td>
<td>2000</td>
</tr>
<tr>
<td>1990</td>
<td>500 patients</td>
<td>500</td>
</tr>
<tr>
<td>2000</td>
<td>250 patients</td>
<td>150</td>
</tr>
</tbody>
</table>

**HG HYGIENE**

- Amalgam Mixing
- Amalgam Storage
- Hg Spill

**PLUMBING**

- Sink Traps and Plumbing
- Suction Mini Trap
- Chairside Filter
- Separation Filter or Trap

**Environmental Issues**

- Air, Water, Land, Food
- US EPA OSHA FDA NAS
STUDY QUESTIONS:

1. Which one of the following online-ordering sites truly exists?
   a. DentalBuy.com
   b. NET32.com
   c. OnlineDentalSupplies.com
   d. DentalSavings.com
   e. DentalProducts.com

2. Which one of the following is NOT a category of dental composites?
   a. Packables
   b. Flowables
   c. Nanocomposites
   d. Microfills
   e. A.R.T.

3. What types of fillers are mixed together in standard hybrid composites?
   a. Midifiller and Minifiller
   b. Minifiller and Microfiller
   c. Microfiller and Nanofiller
   d. Midifiller and Microfiller
   e. Minifiller and Nanofiller

4. What types of fillers are mixed together in mini-hybrid composites?
   a. Midifiller and Minifiller
   b. Minifiller and Microfiller
   c. Microfiller and Nanofiller
   d. Midifiller and Microfiller
   e. Minifiller and Nanofiller

5. What types of fillers are mixed together in nano-hybrid composites?
   a. Microfiller and Nanofiller
   b. Minifiller and Nanofiller
   c. Microfiller and Nano-clusters
   d. Microfiller and Nanomers
   e. Nanomers, Nanoclusters, and Midifiller

6. Nanofillers are produced by which of the following processes?
   a. Coarse grinding of powders
   b. Fine grinding of powders
   c. Sol-gel processes
   d. Vapor phase deposition
   e. Spraying liquid silica

7. Which one of the following is not a true statement about biofilms?
   a. The base layer involves cells attached by a polysaccharide coating.
   b. Biofilms have extensive channels among mushroom plumes of cells.
   c. Biofilms can migrate across a surface to relocate the entire film.
   d. Cells in biofilms easy destroyed by standard antibiotics.
   e. Biofilms are found universally in moist environments regardless of bacterial cell type.
8. Which one of the following statements characterizes second generation flowable composites?
   a. Much better flow than first generation products.
   b. All products are almost the same strength as standard hybrid composites.
   c. Much greater depth of cure than regular composites.
   d. Do not adapt well to bonded dentin surfaces.
   e. Are more difficult to cure with visible light than other composites.

9. Which one of the following materials is NOT a packable composite?
   a. Filtek Supreme
   b. SureFil
   c. A.L.E.R.T.
   d. Prodigy Condensable
   e. Solitaire 2

10. Which one of the following is an expanding monomer?
    a. Hydroxyethyl methacrylate (HEMA)
    b. BIS-GMA
    c. Methyl methacrylate (MMA)
    d. Oxirane
    e. Silane

11. What is DOXADENT?
    a. Nanocomposite produced in Europe
    b. Flowable composite
    c. Directly-placed ceramic restoration
    d. LED curing light
    e. Powered toothbrush

12. Which of the following is NOT a category of dentin bonding systems?
    a. 3-component total-etch system
    b. 2-component total-etch system
    c. 2-component self-etching primer (SEP)
    d. 1-component self-etching adhesive (SEA)
    e. 0-component self-etching composite (SEC)

13. What is the reason for applying several coats of primers, self-etching primers, or self-etching adhesives during bonding procedures?
    a. Insure adequate film formation after solvent loss
    b. Increase the strength of the bonding layer
    c. Increase the water resistance of the cured film
    d. Increase the fatigue resistance of the adhesive
    e. To minimize oxygen inhibition during VL curing

14. What is the typical solvent level range for dentin bonding systems?
    a. 10-30%
    b. 20-50%
    c. 45-50%
    d. 55-60%
    e. 60-90%
15. What is the hybrid layer?
   a. Zone of collagen surrounded by resin within intertubular dentin
   b. A layer of resin in which there is a combination of filler particle sizes
   c. A double layer produced by primer and then bonding agent
   d. Resin that has mixed with dentinal fluid and filled the tubules
   e. Any resin layer that includes HEMA in the composition

16. What is the third major category of variables affecting visible light curing in addition to “curing equipment factors” and “procedural factors”?
   a. Restoration factors
   b. Patient factors
   c. Intraoral location factors
   d. Oral hygiene factors
   e. Surface contamination factors

17. Which one of the following is NOT a category of visible light curing units?
   a. Argon laser curing units
   b. L.E.D. curing units
   c. RF curing units
   d. Quart-Tungsten-Halogen curing units
   e. Plasma arc curing units (PAC)

18. What is the active absorber of visible light in a dental composite that initiates polymerization?
   a. BIS-GMA
   b. Glass filler
   c. Silane coupling agent
   d. Camphoroquinone
   e. Hydroquinone

19. What is the minimum output expected for standard QTH visible light curing units?
   a. 100 mW/cm²
   b. 200 mW/cm²
   c. 300 mW/cm²
   d. 400 mW/cm²
   e. 600 mW/cm²

20. What is the standard operating output for many QTH visible light curing units?
   a. 100 mW/cm²
   b. 300 mW/cm²
   c. 600 mW/cm²
   d. 1000 mW/cm²
   e. 1500 mW/cm²

21. What is the standard output for third-generation LED visible light curing units?
   a. 100 mW/cm²
   b. 200 mW/cm²
   c. 300 mW/cm²
   d. 600 mW/cm²
   e. 800-1000 mW/cm²
22. What happens to the visible light generated by QTH units that is not the correct wavelength to be absorbed by CQ?
   a. Passes completely through restorative material
   b. Scattered by the glass filler particles into adjacent tooth structure
   c. Absorbed and converted into heat
   d. Reflected by the surface of the restoration as light
   e. Absorbed and re-emitted as infrared light

23. What is the largest volume of glass ionomer sold in the world today?
   a. Giomer
   b. Compomer
   c. Resin-modified glass ionomer
   d. Conventional glass ionomer
   e. Resin-reinforced glass ionomer for ART technique

24. What is the reason for BMPs?
   a. Provide legal protection for dentistry against OSHA
   b. Insure a healthy workplace and recycle hazardous materials
   c. Eliminate the use of dental amalgam in the dental office
   d. To protect patients from hazards of high-intensity visible-curing lights
   e. Insure infection control involving dental materials

25. What is the best management practice for insuring the greatest Hg/amalgam recycling?
   a. Chair-side filters
   b. Suction line separators
   c. Non-contact amalgam recovery
   d. Office vacuums for collecting spilled Hg
   e. Special traps on sinks