Im Klinikalltag angekommen? Antimikrobielle Konstruktionswerkstoffe auf Basis masiven Kupfers

Forschung und Praxis: aktueller Stand

Dr. Anton Klassert, Deutsches Kupferinstitut Berufsverband e.V.

13. Kongress für Krankenhaushygiene der DGKH
Berlin, 13. April 2016

Deutsches Kupferinstitut
Copper Alliance

Antimicrobial Copper

Agenda

- Nosokomiale Infektionen als medizinisches, soziales und ökonomisches Problem
- Anforderungen an ein Hygienekonzept
- Klinische Studien - weltweit
- Antimikrobielle Kupferlegierungen:
  Umsetzung in die Praxis
- Deutsche Gesundheitseinrichtungen rüsten um
- Zusammenfassung und Ausblick

Wer wir sind

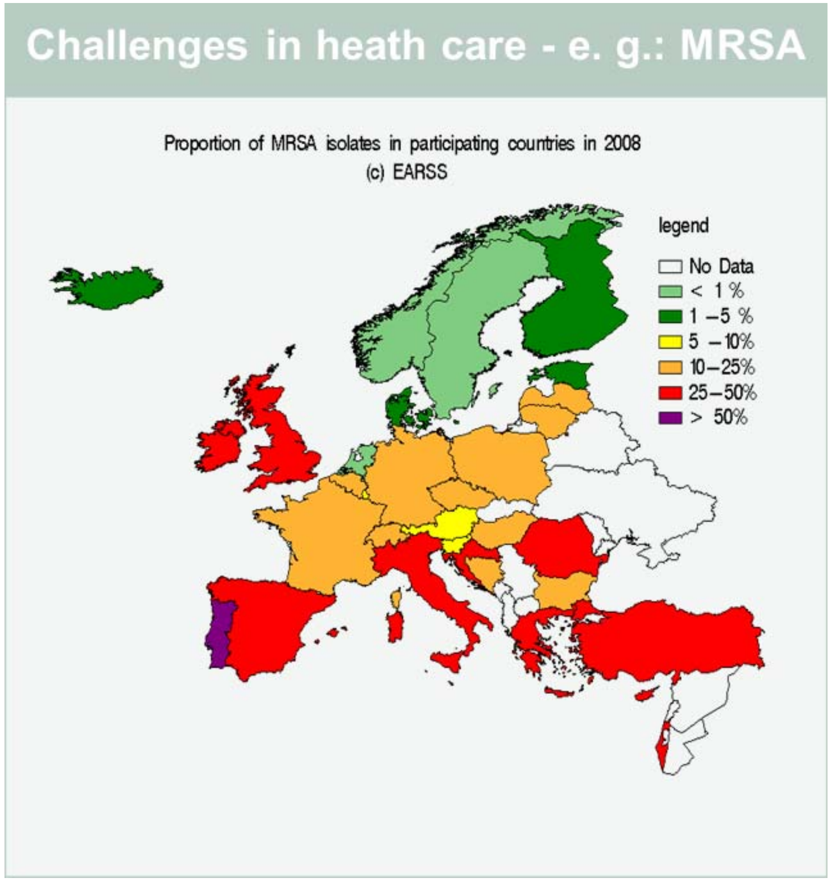
Deutsches Kupferinstitut
Copper Alliance

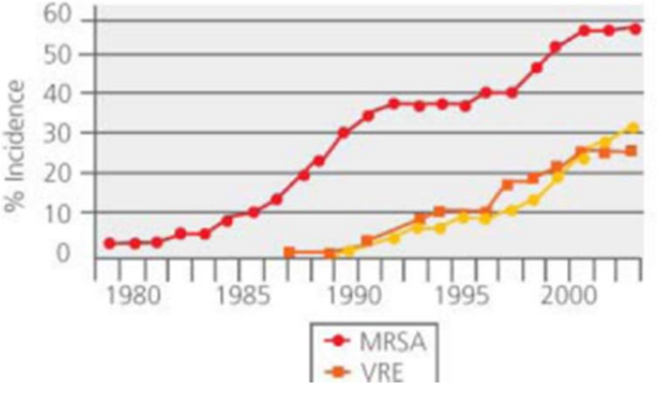
Technologie		
Zuhören Beraten	Wissen Vermitteln	Forschen Anwenden
Anfragen Vernetzen Ingenieurleistungen	Publikationen (Web, Print) Seminare Symposien, Workshops	Datenermittlung Materialoptimierung Anwendungsentwicklg.

Antimicrobial Copper

Teil eines globalen Netzwerkes:
150 Mitarbeiter / 50+ M $/a

Zunehmende Bedrohung durch resistente Pathogene





Quelle: EARSS

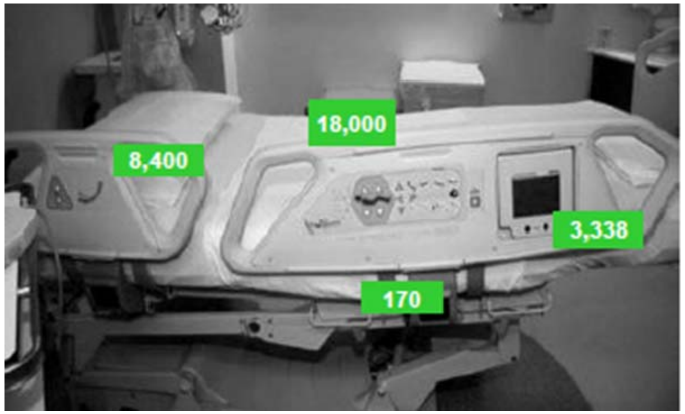
Anforderungen an ein Hygienekonzept

4-Säulen-Strategie des Robert Koch-Instituts

Identifizierung, Erfassung und Bewertung von MRSA (Screening)	Strikte Umsetzung geeigneter Hygiene-maßnahmen	Sanierung von MRSA-Trägern	Kontrollierter Einsatz von Antibiotika

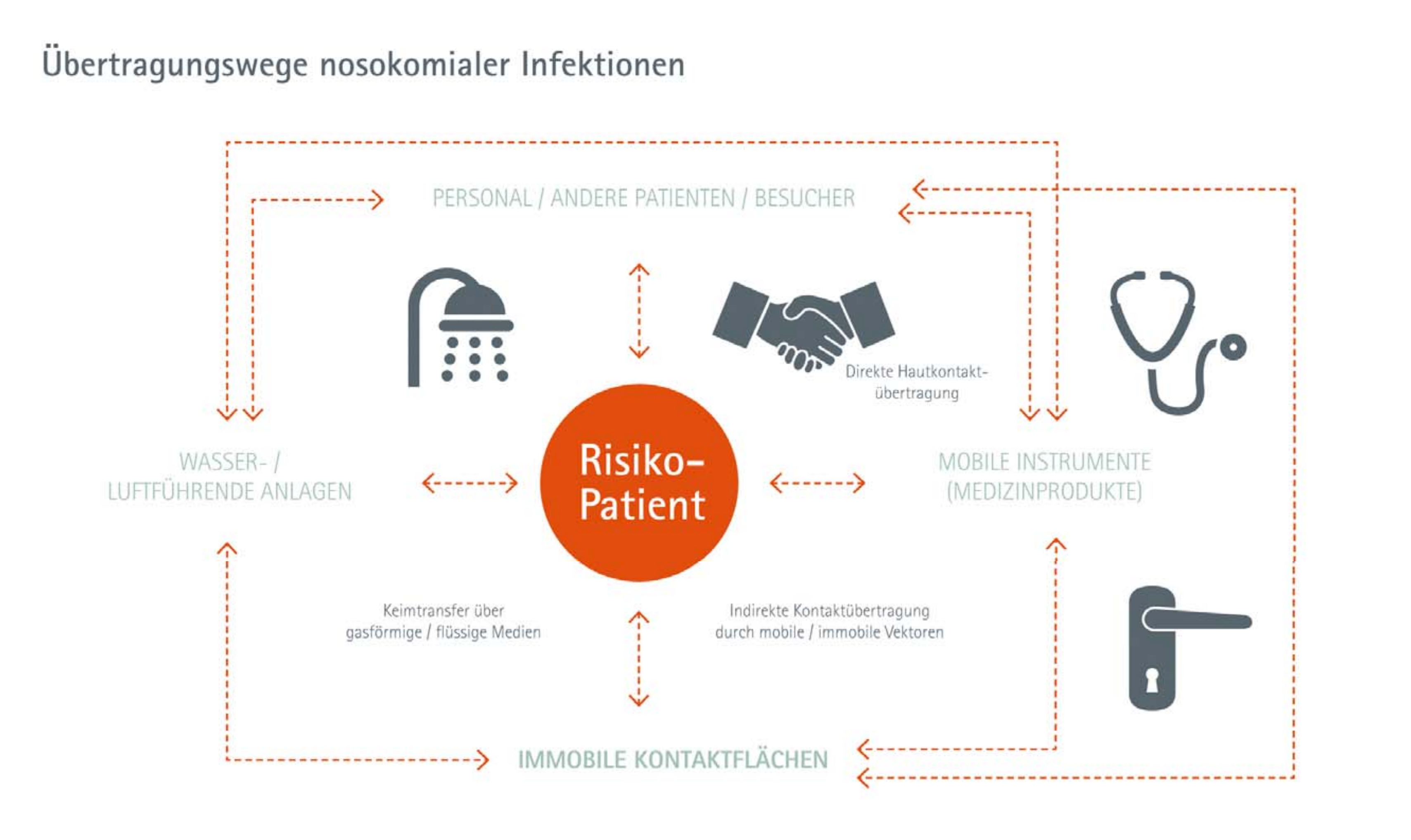
Quelle: Robert Koch- Institut

Anforderungen an ein Hygienekonzept
Keimbelastung von Oberflächen/ Momentaufnahmen



Grün = Keimbelastung von Oberflächen (KbE/100cm²)

Anforderungen an ein Hygienekonzept



Antimicrobial Copper Cu+

Anforderungen an ein Hygienekonzept

Hot Spots der Keimübertragung

Antimicrobial Copper Cu+

Nosokomiale Infektionen als medizinisches, soziales und ökonomisches Problem

- Nosokomiale Infektionen stellen eine Gefahr für die medizinische Versorgung dar; dies betrifft in besonderem Maße die hochtechnisierte Intensivmedizin.
- Rund 70 % aller Bakterien, die Infektionen in Krankenhäusern verursachen, sind gegen mindestens ein Antibiotikum resistent
- Herausforderung an medizinische Versorgung und Pflegestrukturen wächst
- Der wirtschaftliche Schaden durch nosokomiale Infektionen beläuft sich allein in Europa auf 5,5 Milliarden Euro/Jahr

Standards integrativ und interdisziplinär erweitern:

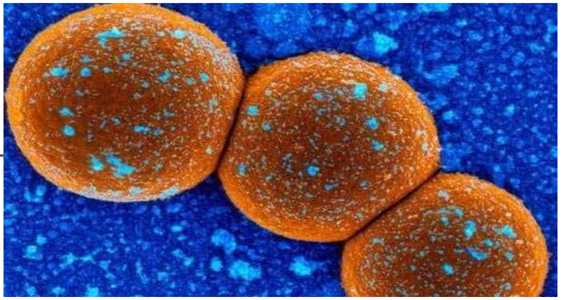
Standardhygiene + Desinfektion + Unterstützung der Flächenhygiene durch den Einsatz innovativer Materialien

Intrinsische antimikrobielle Eigenschaften von Kupfer als zusätzliche Unterstützung existierender Präventionsmaßnahmen

Eine Option gegen die Ausbreitung pathogener Keime ist der Einsatz eines dauerhaft wirksamen antimikrobiellen Materials für häufig berührte Kontaktflächen.

Massives Kupfer sowie die meisten seiner Legierungen mit mindestens 60 % Kupfergehalt erreichen eine Inaktivierung von Krankheitserregern innerhalb weniger Minuten bzw. Stunden, je nach verwendetem Testverfahren.

Gegen welche pathogenen Organismen wirkt Kupfer antimikrobiell?



Sensitivität verschiedener Organismen gegenüber antimikrobiellen Kupferlegierungen

Acinetobacter baumannii	EMRSA-16e (NCTC13143)	Methicillin-resistant Staphylococcus aureus (MRSA)
Acinetobacter johnsonii DSM6963	Enterobacter aerogenes	MRSA NCTC 10442
Adenovirus	Enterococcus hirae ATCC 9790	MRSAd (NCTC10442)
Aspergillus flavus	Escherichia coli 0157:H7	Mycobacterium tuberculosis
Aspergillus fumigatus	Escherichia coli 0157	Pantoea stewartii DSM30176
Aspergillus niger	Escherichia coli W3110	Penicillium crysogenum
Brachybacterium conglomeratum DSM 10241	Fusarium culmonium	Poliovirus
Clostridium difficile (ATCC 9689) vegetative cells and spores	Fusarium oxysporum	Pseudomonas aeruginosa
C. difficile NCTC11204/R20291 vegetative cells	Fusarium solani	Pseudomonas aeruginosa PAO1
C. difficile dormant spores	Helicobacter pylori	Pseudomonas oleovorans DSM 1045
C. difficile germinating spores	Influenza A (H1N1)	Saccharomyces cerevisiae
Candida albicans	Klebsiella pneumoniae	Salmonella enterica
Campylobacter jejuni	Legionella pneumophila	Salmonella enteritidis
Different Enterococcus spp.	Listeria monocytogenes	Staphylococcus warnerii DSM20316
EMRSA-1e (NCTC11939)	Listeria monocytogenes Scott A	Vancomycin-resistant enterococcus (VRE)

Kernbotschaften / Philosophie im Überblick

1. *Fachspezifisch:* breites Wissen über Kupfer vorhanden, aber nicht interdisziplinär vernetzt

→ Kupfer als WIRKstoff in Biologie und Medizin

→ Kupfer als WERKstoff in technischen Applikationen

2. *Interdisziplinärer:* Wissensaustausch und F&E:

→ Mehrwert in Grundlagenverständnis

3. *Philosophie:*

→ Nutzung des Mehrwerts in der Anwendung

→ Kombination aus „Top down“ und „Bottum up“ Ansatz

Antimicrobial Copper Cu+

Herausforderung:
Sachstandanalyse und Schlussfolgerungen

Antimicrobial Copper Cu+

Metallurgie / Physik / Werkstoff-Forschung:

Kupferlegierungen (1): Grundlagen

Farbeigenschaften

Sn Ni

Härte / Stabilität

Al Si Mn Cr Ni Be Sn Fe Ag

Maschinelle Bearbeitbarkeit

Nb Ti Si Pb

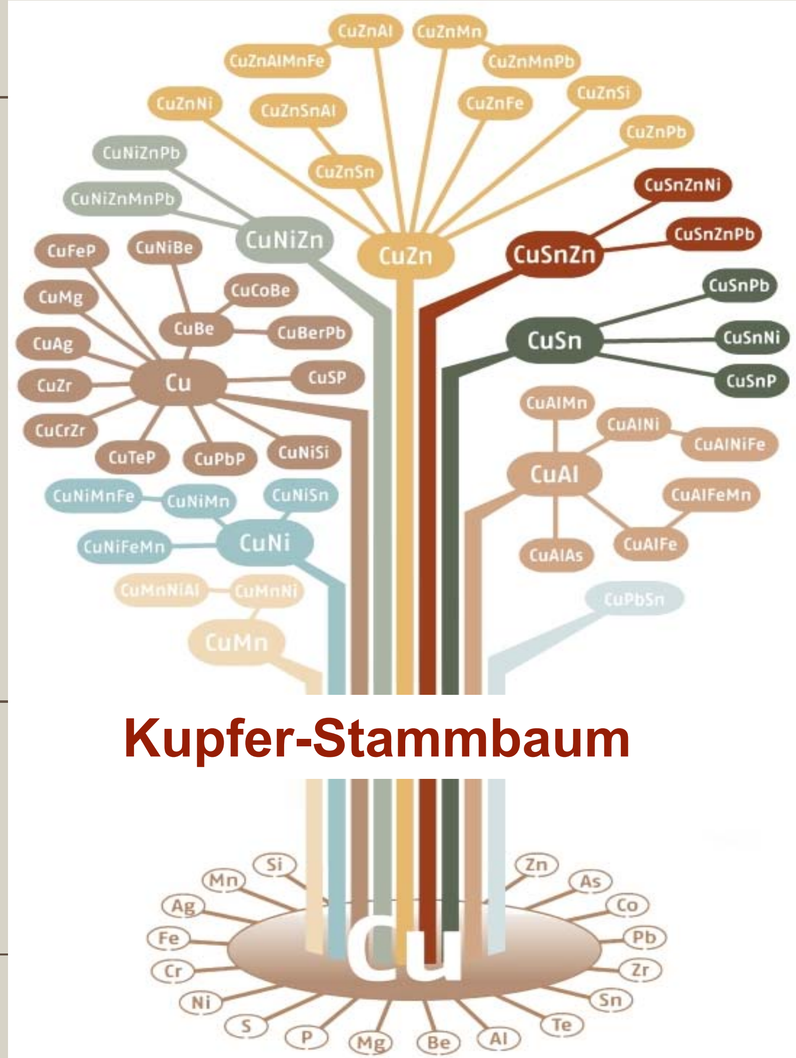
Cu

Ni Fe Al Sn

Korrosionsresistenz

Al Cr Sn Fe

Verschleißresistenz



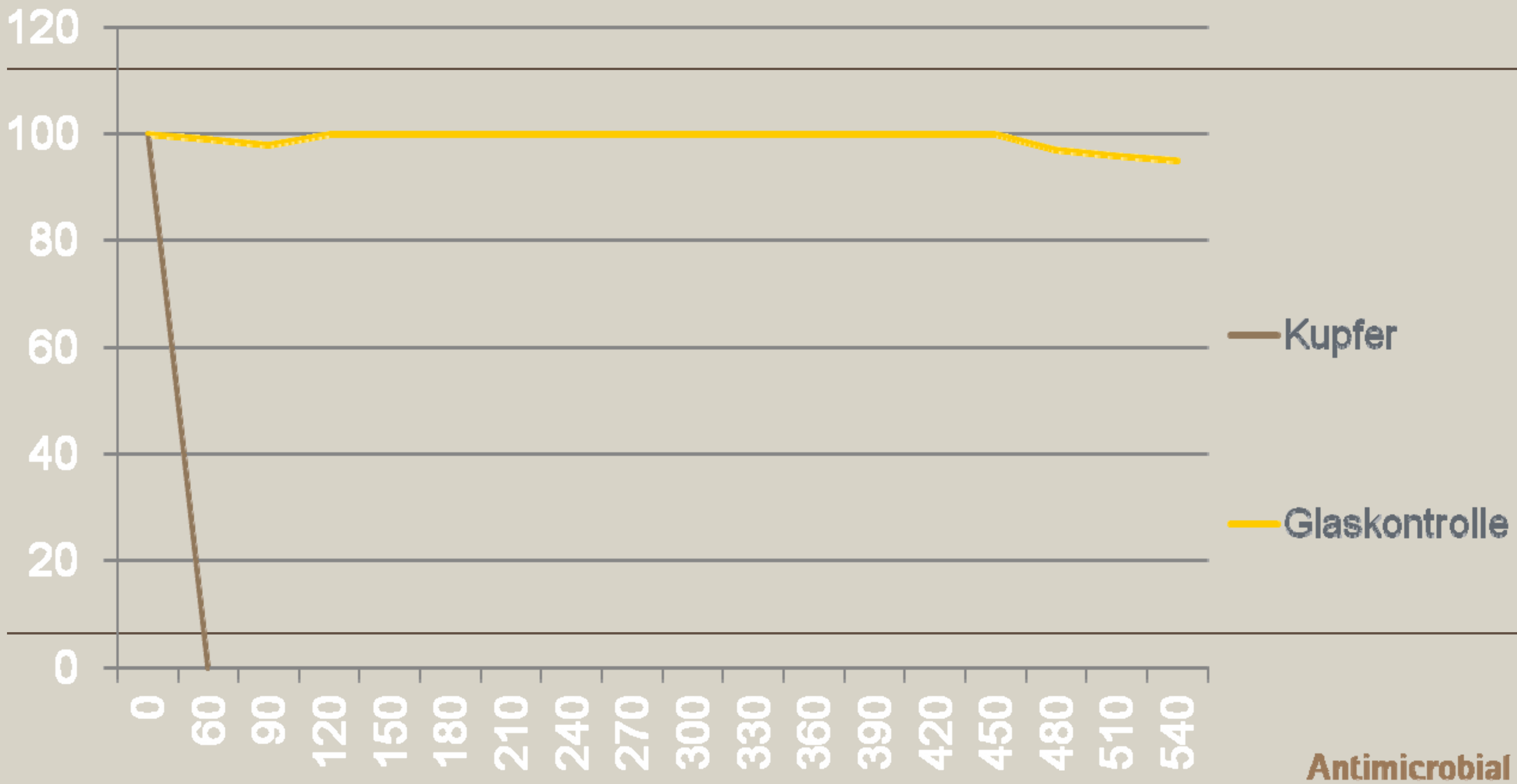
Antimikrobielle Kupferlegierungen – Umsetzung in die Praxis

Auswahl geeigneter Kupferlegierungen

- Keine Beschichtungen, sondern massiv
- Kratzfeste Oberfläche
- Anlaufbeständige Oberfläche
- Wirtschaftliche Herstellung
- Kupfergehalt > 60 %
- Breites Produktspektrum
- Keine Zugabe von Chemikalien
- Unschädlich für Mensch und Umwelt
- Breite Palette von Formen, Farben und Oberflächen

Metallurgie / Physik / Werkstoff-Forschung:

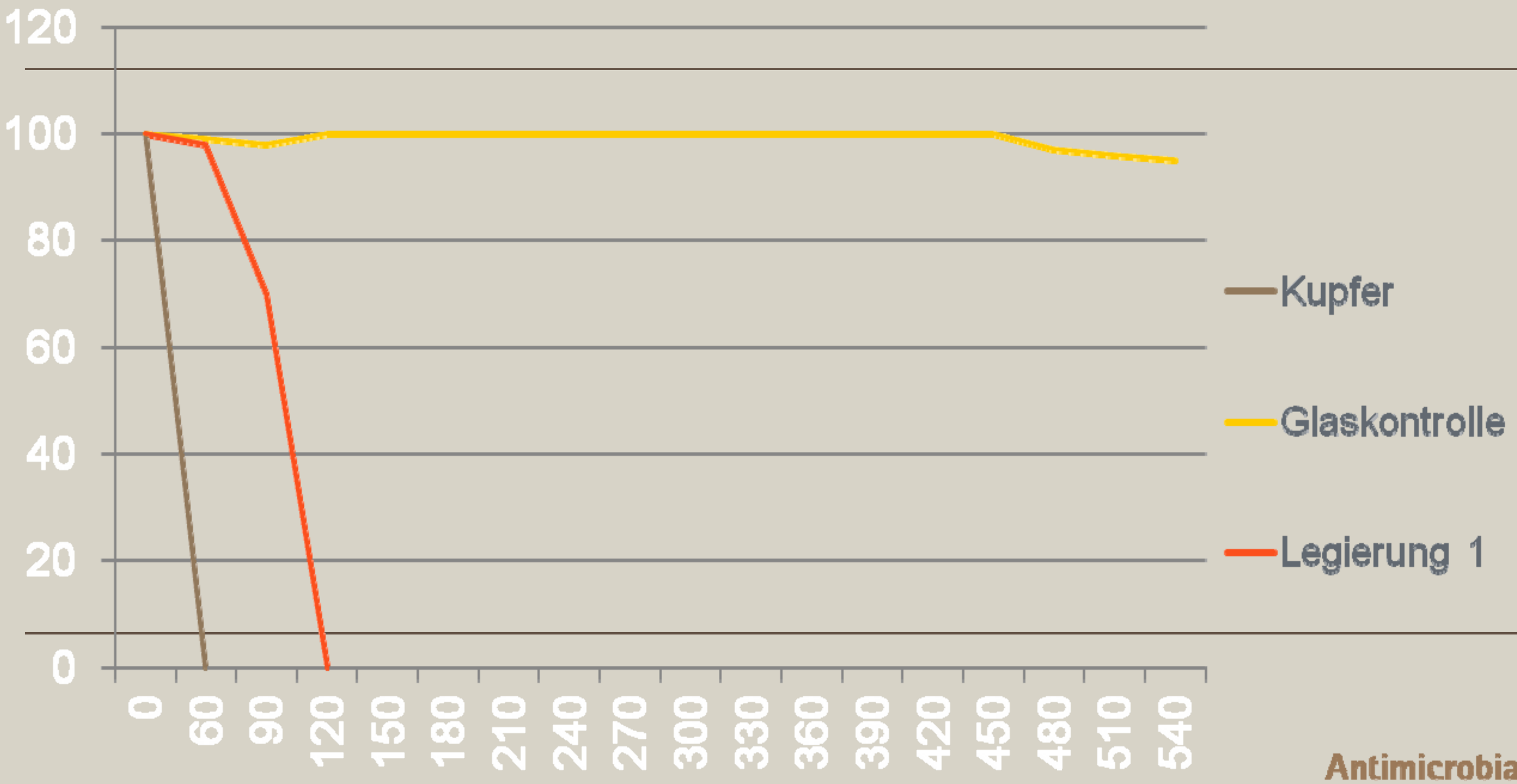
Kupferlegierungen (3): Antimikrobielle Kraft - Versuche



Antimicrobial Copper Cu+

Metallurgie / Physik / Werkstoff-Forschung:

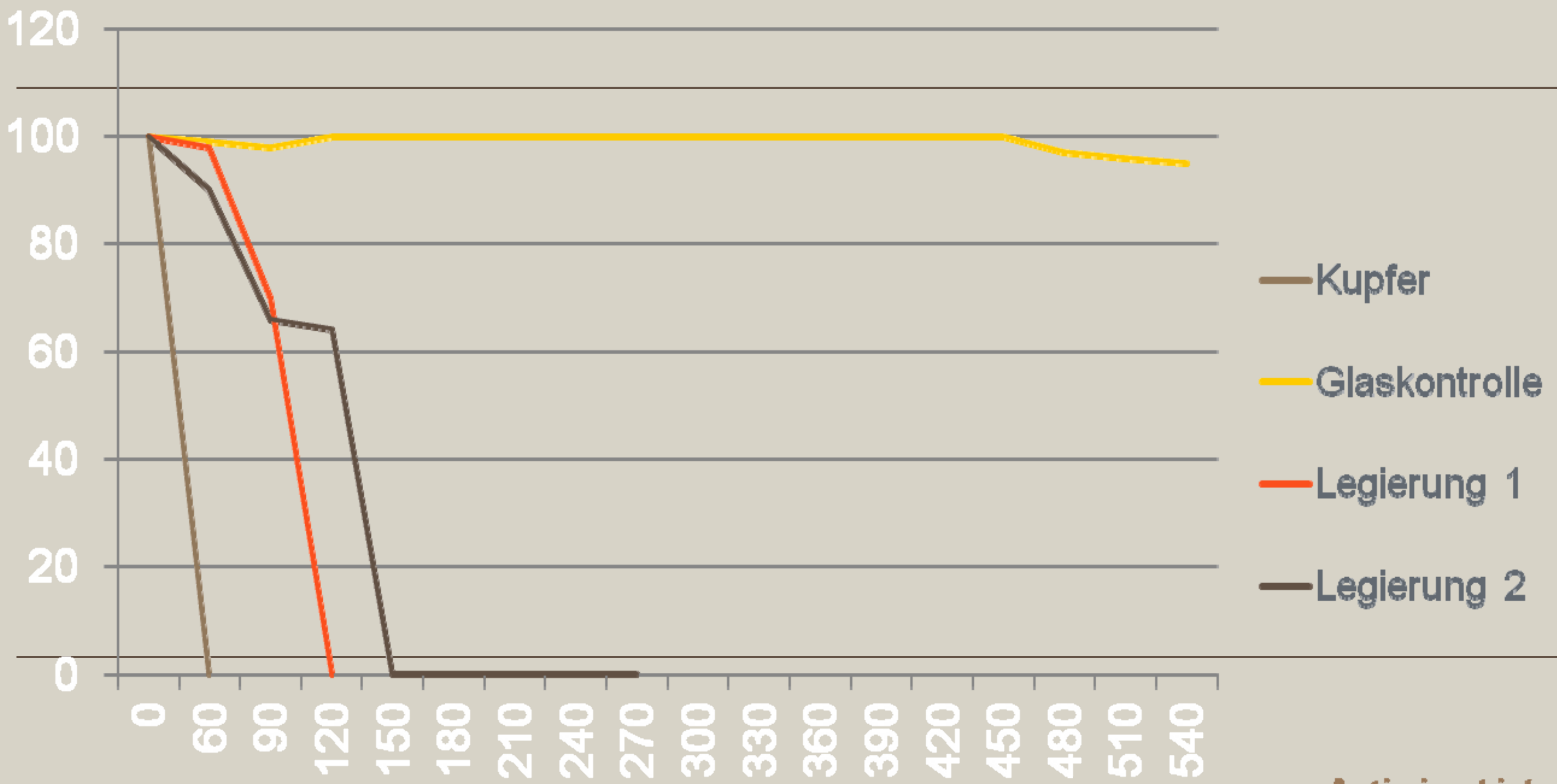
Kupferlegierungen (3): Antimikrobielle Kraft - Versuche



Antimicrobial Copper Cu+

Metallurgie / Physik / Werkstoff-Forschung:

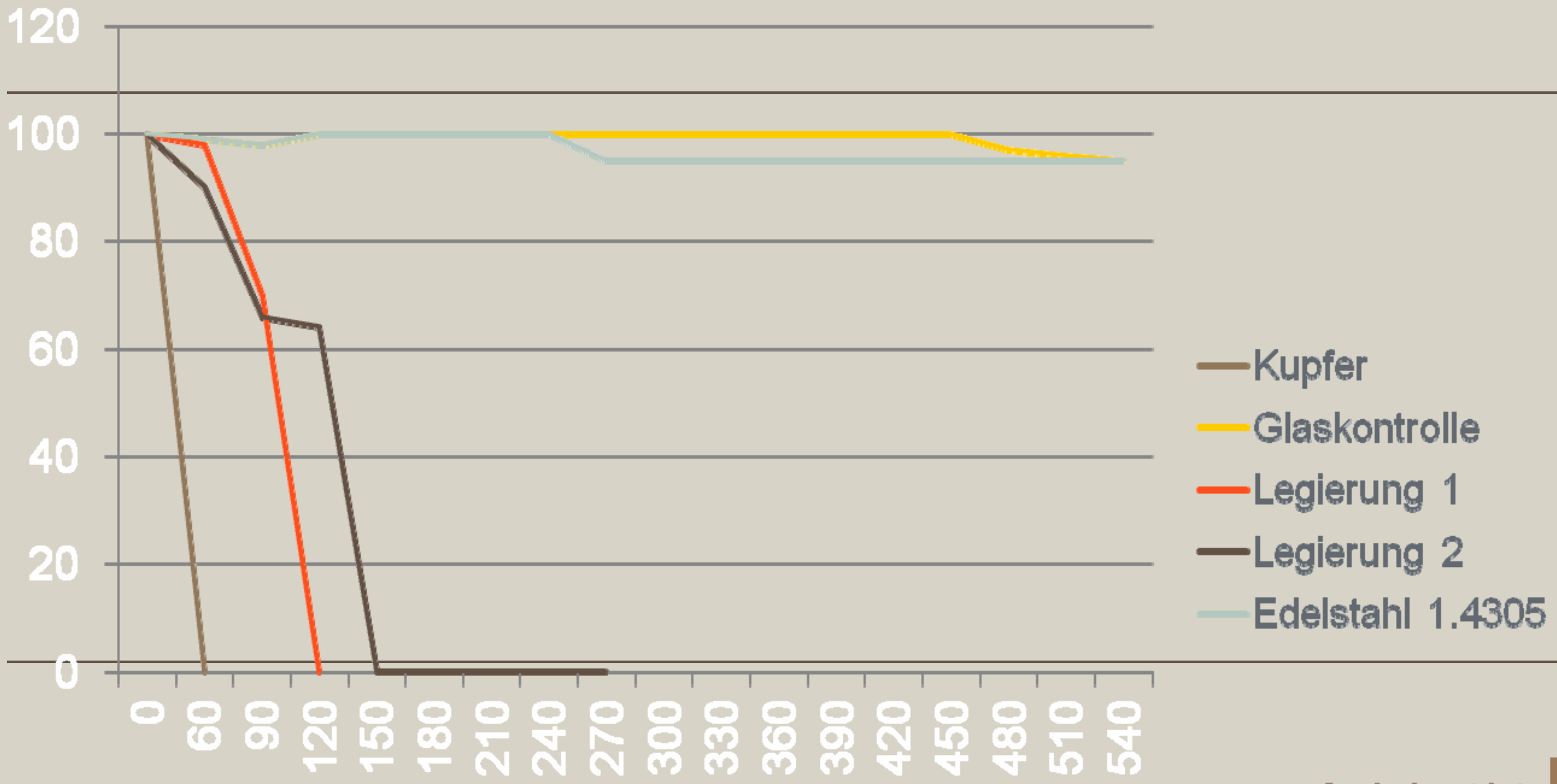
Kupferlegierungen (3): Antimikrobielle Kraft- Versuche



Antimicrobial Copper

Metallurgie / Physik / Werkstoff-Forschung:

Kupferlegierungen (3): Antimikrobielle Kraft – Versuche



Antimicrobial Copper Cu+

Antimikrobielle Kupferwerkstoffe in der Praxis

(2): z. B. Schnittstelle Bakteriologie / Werkstoff F&E: DfG / SNF

zam00813/zam4300d13z | xppws | S=1 | 3/1/13 | 18:39 | ArtID: 03608-12 | NLM: research-article | CE: jaw
Editor: Spormann | Section: Environmental Microbiology | Designation: T

AEM Journals.ASM.org

Contact Killing of Bacteria on Copper Is Suppressed if Bacterial-Metal Contact Is Prevented and Is Induced on Iron by Copper Ions

AQ: au Salima Mathews,[a] Michael Hans,[b] Frank Mücklich,[b] Marc Solioz[a]
Department of Clinical Research, University of Bern, Bern, Switzerland[a]; Department of Materials Science, Functional Materials, Saarland University, Saarbrücken, Germany[b]

Bacteria are rapidly killed on copper surfaces, and copper ions released from the surface have been proposed to play a major role in the killing process. However, it has remained unclear whether contact of the bacteria with the copper surface is also an important factor. Using laser interference lithography, we engineered copper surfaces which were covered with a grid of an inert polymer which prevented contact of the bacteria with the surface. Using *Enterococcus hirae* as a model organism, we showed that the release of ionic copper from these modified surfaces was not significantly reduced. In contrast, killing of bacteria was strongly attenuated. When *E. hirae* cells were exposed to a solid iron surface, the loss of cell viability was the same as on glass. However, exposing cells to iron in the presence of 4 mM $CuSO_4$ led to complete killing in 100 min. These experiments suggest that contact killing proceeds by a mechanism whereby the metal-bacterial contact damages the cell envelope, which, in turn, makes the cells susceptible to further damage by copper ions.

AQ: A The rapid killing of bacteria by solid copper surfaces has recently received much attention. In laboratory experiments, it had been shown that many bacterial species, such as *Escherichia coli* O157, *Staphylococcus aureus*, *Salmonella enterica*, *Campylobacter jejuni*, *Clostridium difficile*, *Listeria monocytogenes*, and *Mycobacterium tuberculosis*, are efficiently killed on copper or copper alloy surfaces (1–8). In contrast, on stainless steel, living cells could be recovered even after days. Copper and many copper alloys have consequently been registered at the U.S. Environmental Protection Agency as the first solid antimicrobial material. This has moved copper into the focus of infection control. Nosocomial infections are an increasing problem throughout the world and cost many lives (9). A number of hospital trials in which rooms have been fitted with copper alloy door handles, bathroom fixtures, tabletops, etc., have been conducted or are ongoing (10–14). They have shown that on copper surfaces, there is a substantial reduction of the microbial burden on a continuous basis. While further data are needed, it is clear that copper-containing materials can contribute to hospital hygiene, but they also lower the bacterial burden in other facilities where clean or aseptic working procedures are required (15).

With the use of copper in hospitals and other facilities, it has become important to understand the mechanism of the so-called "contact killing" of bacteria, as it may bear on the possibility of the emergence of resistant organisms, on cleaning procedures, and on material and object engineering. From laboratory studies, it has emerged that bacteria on copper surfaces suffer rapid membrane damage and DNA degradation, in addition to other, less well-defined cell damage (16–21). The order in which these processes take place and which one is the primary killing mechanism remain issues of debate. In fact, the sequence of events may depend on the type of microorganism (18). It is also clear that copper ions released from the surface play a role in contact killing, but bacterial copper resistance systems are not able to cope with the released copper (2, 22, 23).

A question which has not yet been addressed in detail is the role of physical contact of bacteria with the copper surface in contact killing. We thus engineered special copper surfaces, so-called "contact arrays": copper surfaces were covered by an inert polymer into which arrays of holes less than 1 μm in diameter were etched by a photolithographic process, using laser interference (24). *Enterococcus hirae* was used as a model organism because Gram-positive organisms are frequent pathogens and the contact killing behavior of *E. hirae* had previously been studied (23). Also, its robust cell wall helped to preserve the shape of the bacteria during electron microscopy. The holes in the contact arrays were smaller than *E. hirae*, so the grid effectively prevented contact of the bacteria with the copper surface. It was found that contact killing on these contact arrays was reduced by 7 orders of magnitude compared to copper coupons, while the release of ionic copper was not significantly altered. AQ: B Metallic iron did not appear to be active in contact killing, unless copper ions were also present. These experiments demonstrate the importance of both copper ions and bacterial-metal contact for efficient contact killing.

MATERIALS AND METHODS

Bacterial strains and growth conditions. Wild-type *E. hirae* ATCC 9790 was grown anaerobically (air-saturated medium was transferred to sealed tubes; these cultures became anaerobic after approximately 1 h) to stationary phase at 37°C in 10 ml of N medium (25). Cells were centrifuged for 5 min at 5,000 × g, washed twice with 20 ml of 100 mM Tris-Cl (pH 7), and resuspended in 10 ml of the same buffer. The average cell density was 2×10^8 to 8×10^8 CFU/ml. All handling of cells was performed aerobically.

Coupons and contact arrays. Control C1 copper coupons were 15- by 15-mm squares of highly polished (root mean square roughness < 50 nm), 99.99% pure copper and were cleaned by ultrasonication in chloroform and ethanol for 10 min each, followed by air drying. CA contact arrays were prepared by spin coating C1 coupons with cresol resin AZ AQ: C

Received 21 November 2012 **Accepted** 4 February 2013
Published ahead of print 8 February 2013
Address correspondence to Marc Solioz, marc@solioz-scientific.ch, or Frank Mücklich, muecke@matsci.uni-sb.de.
S.M. and M.H. contributed equally to this article.

doi:10.1128/AEM.03608-12

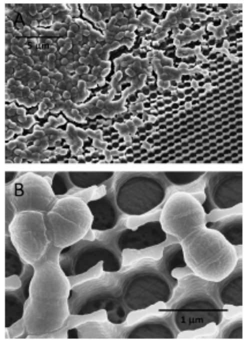


FIG 2 SEM image (tilted view) of bacteria on a contact array. *E. hirae* cells were wet plated on a CA contact array. After air drying, the sample was processed for electron microscopy as described in Materials and Methods. (A) Image at low magnification; (B) image at high magnification.

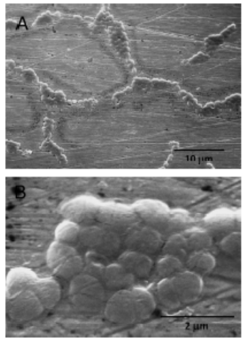


FIG 3 SEM images of bacteria on a polished copper coupon. *E. hirae* cells were wet plated on a C1 copper coupon. After air drying, the sample was processed for electron microscopy as described in Materials and Methods. (A) Image at low magnification; (B) image at high magnification.

was obtained: there was no significant contact killing (Fig. 4B). Even after 3.5 h, cell survival was reduced only by 1 log (data not shown). In contrast, uncoated C1 copper coupons completely killed >10^6 bacteria in 30 min, in line with previous reports on contact killing of various bacterial species (e.g., see reference 19). This suggested that curtailing bacterial-metal contact on the CA arrays effectively prevented contact killing. However, it remained to be shown that copper release was not impaired on the CA contact arrays.

Copper release by copper coupons and contact arrays. To test whether the lack of killing by CA contact arrays was due to reduced release of copper ions, copper release was measured. F5 Figure 5 shows that the release of copper ions was not significantly different between C1 copper coupons and CA contact arrays. The concentrations of released copper in the aqueous phase after 30 min were 8.8 ± 0.2 mM for C1 copper coupons and 7.9 ± 1.8 mM for CA contact arrays; the difference between these values was not statistically significant. This clearly shows that the failure of CA contact arrays to support efficient contact killing was not due to reduced copper release; rather, it appeared that the inability of the bacteria to make contact with the copper surface prevented contact killing.

Contact killing on iron coupons. Iron and copper have similar redox potentials for the most oxidized ion couples, and both elements can catalyze Fenton chemistry (see Discussion). Thus, they both have the potential to damage cells, and it was of interest to test the activity of iron in contact killing. Surprisingly, contact killing by iron has never been investigated as far as we know. F6 Figure 6 shows that there was insignificant contact killing of *E. hirae* over 300 min on iron. However, adding 4 mM $CuSO_4$ to the cells before plating on iron led to complete killing of 2×10^7 cells in 100 min. The same copper concentration on glass also led to some killing, but this was orders of magnitude less than on iron: after 300 min, 10^4 CFU could still be recovered. The concentration dependence of the Cu-induced contact killing on iron could best be observed at 10 min, where survival was intermediate: survival decreased exponentially with increasing copper concentrations and reached zero at 10 mM $CuSO_4$ (Fig. 6, inset). Under these conditions, there was still 73% survival on glass (data not shown). Thus, ionic copper and metallic iron acted synergistically to effect efficient contact killing of *E. hirae*. There was no adherence of bacteria to the iron coupons, as mechanical removal by vortexing with glass beads yielded the same results (not shown). Iron release from the coupons into the aqueous phase in the presence of cells at 100 min amounted to 5.5 ± 2.8 mM in the absence of copper ions and 12.6 ± 0.4 mM in the presence of 4 mM $CuSO_4$. After 300 min, the respective values were 15.6 ± 4.4 mM and 22.4 ± 1.0 mM. However, iron is not very soluble under aerobic conditions at pH 7.5, and it must be assumed that most of the iron was present in the hydroxide form and that free Fe^{3+} remained very low. In fact, the formation of a visible film on the surface of the aqueous phase could be observed. So iron release is unlikely to play a role in contact killing by metallic iron. Rather, our results suggest a mechanism of contact killing whereby the contact of the bacteria with solid iron or copper weakens the bacterial cell wall and/or membrane, which, in turn, renders the cells susceptible to damage by copper ions. In the absence of the toxic effects of ionic copper,

Metallurgie / Physik / Werkstoff-Forschung:

Kupferlegierungen (3): Antimikrobielle Kraft – Take Home

F&E mit MASSIVEN metallischen Kupferlegierungen (Voll-Material)

→ Ergebnisse NICHT gültig für Beschichtungen jedweder Art

→ Kupferlegierungen mit min. 65% Kupferanteil wirksam

Antimicrobial Copper Cu+™

Antimikrobielle Kupferlegierungen – Umsetzung in die Praxis

Antimicrobial Copper: eine globale Marke steht für Sicherheit und Qualität

- **Die Marke Cu+, Antimicrobial Copper TM, gilt als weltweites Qualitätszeichen für antimikrobielle Kupferlegierungen. Das Zeichen dient als Bestätigung, dass die betreffenden Produkte eine optimale antimikrobielle Wirkung besitzen.**

- **Deutsche Cu+ Produkt-Partner**
  - ALBRECHT JUNG GMBH & CO. KG
  - Wilhelm May GmbH
  - FSB

Klinische Studien – weltweit

- **2005: Kitasoto University Hospital, Japan (Vor-Studien)**
- **2007: Selly Oak Hospital, Birmingham, GB**
- **2008/2009: Asklepios Klinik Wandsbek, Hamburg**
- **2009: Hospital del Cobre, Calama, Chile**
- **2010/2011: Medical University of South Carolina, USA, Multi-centerstudie in Kooperation mit Memorial Sloan Kettering Cancer Center, NYC, Ralph H. Johnson VA Hospital, Charleston, SC**

Klinische Studien – weltweit

2007: Selly Oak Hospital, Birmingham, GB

- **Allgemeinstation**
- **Herkömmliche Handläufe, Toilettensitze, Türdrücker, Armaturen und Klinken wurden durch entsprechende Gegenstände Kupfer-legierungen ersetzt**

Krankenhausversuch am Selly Oak Klinikum in Birmingham, UK: Vergleich der KbE-Reduktion zwischen Kupfer und Edelstahloberflächen

Mikroorganismen	Log-Reduzierung (KbE/mL) auf Kupfer	Log-Reduzierung (KbE/mL) auf Edelstahl
E. coli (ESBL)	> 5	0
S. aureus (MRSA)	> 5	0
EMRSA 15	3,8	0
EMRSA 16	4,5	0
E. faecium	3,7	0
C. albicans	> 5	0
K. pneumoniae	> 5	0
A. baumanii	> 4,1	0

Quelle: Casey, A. L., Adams, D., Karpanen, T. J. et al. (2010): Role of copper in reducing hospital environment contamination. Journal of Hospital Infection, 74(1): 72-77

Klinische Studien – weltweit

2008/2009: Asklepios Klinik Wandsbeck, Hamburg

- Onkologisch-pneumologische/ geriatrische Station
- Austausch von 50 Türgriffen/-platten und Lichtschaltern
- Reduzierung der MRSA-Keime auf 63 %
- Trend zu niedrigeren Infektionsraten

Appl Microbiol Biotechnol (2010) 87:1875–1879
DOI 10.1007/s00253-010-2640-1

APPLIED MICROBIAL AND CELL PHYSIOLOGY

Survival of bacteria on metallic copper surfaces in a hospital trial

André Mikolay · Susanne Huggett · Ladji Tikana · Gregor Grass · Jörg Braun · Dietrich H. Nies

Received: 12 March 2010 / Revised: 19 April 2010 / Accepted: 19 April 2010 / Published online: 7 May 2010

Abstract Basic chemistry of copper is responsible for its Janus-faced feature: on one hand, copper is an essential trace element required to interact efficiently with molecular oxygen. On the other hand, interaction with reactive oxygen species in undesired Fenton-like reactions leads to the production of hydroxyl radicals, which rapidly damage cellular macromolecules. Moreover, copper cations strongly bind to thiol compounds disturbing redox-homeostasis and may also remove cations of other transition metals from their native binding sites in enzymes. Nature has learned during evolution to deal with the dangerous yet important copper cations. Bacterial cells use different efflux systems to detoxify the metal from the cytoplasm or periplasm. Despite this ability, bacteria are rapidly killed on dry metallic copper surfaces. The mode of killing likely involves copper cations being released from the metallic copper and reactive oxygen species. With all this knowledge about the interaction of copper and its cations with cellular macromolecules in mind, experiments were moved to the next level, and the antimicrobial properties of copper-containing alloys in an "everyday" hospital setting were investigated. The alloys tested decreased the number of colony-forming units on metallic copper-containing surfaces by one third compared to control aluminum or plastic surfaces. Moreover, after disinfection, repopulation of the surfaces was delayed on copper alloys. This study bridges a gap between basic research concerning cellular copper

A. Mikolay · D. H. Nies (✉)
Institut für Mikrobiologie,

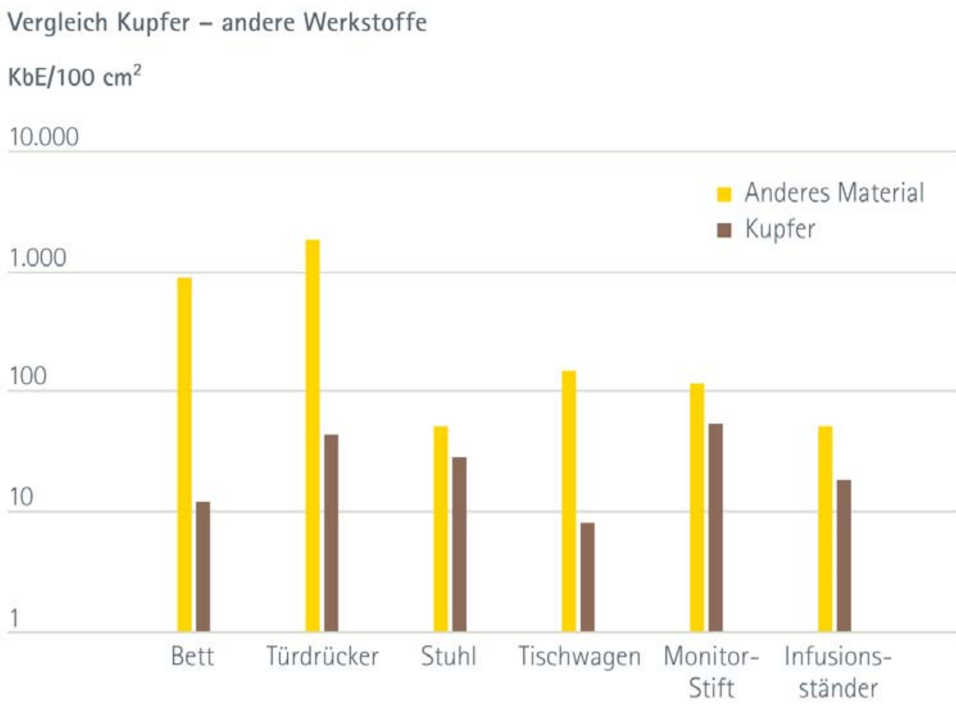
Quelle: Mikolay, A., Huggett, S., Tikana, L. et al. (2010): Survival of bacteria on metallic copper surfaces in a hospital trial. Applied Microbiology and Biotechnology, 87(5): 1875-1879

Antimicrobial Copper Cu+

Klinische Studien – weltweit

2009: Hospital del Cobre, Calama, Chile

- Intensivstation
- 90 Krankenzimmer
- Luftfeuchte 7,2 bis 19,7 %
- Reduktion der Keimzahlen auf Gegenständen aus Kupferlegierungen um bis zu 92 %



Quelle: Prado, V., Durán, C., Crestto, M. et al. (2010): Effectiveness of copper contact surfaces in reducing the microbial burden (MB) in the intensive care unit (ICU) of Hospital del Cobre, Calama

Klinische Studien – weltweit

2010/2011: Medical University of South Carolina, USA

- Multicenterstudie
- Intensivstationen
- 650 Patienten in 16 Krankenzimmern
- Reduktion der Gesamtzahl der pathogenen Keime auf Kupfergegenständen um über 80 %
- Infektionsrate in „Kupferzimmern“ um annähernd 60 % gesunken

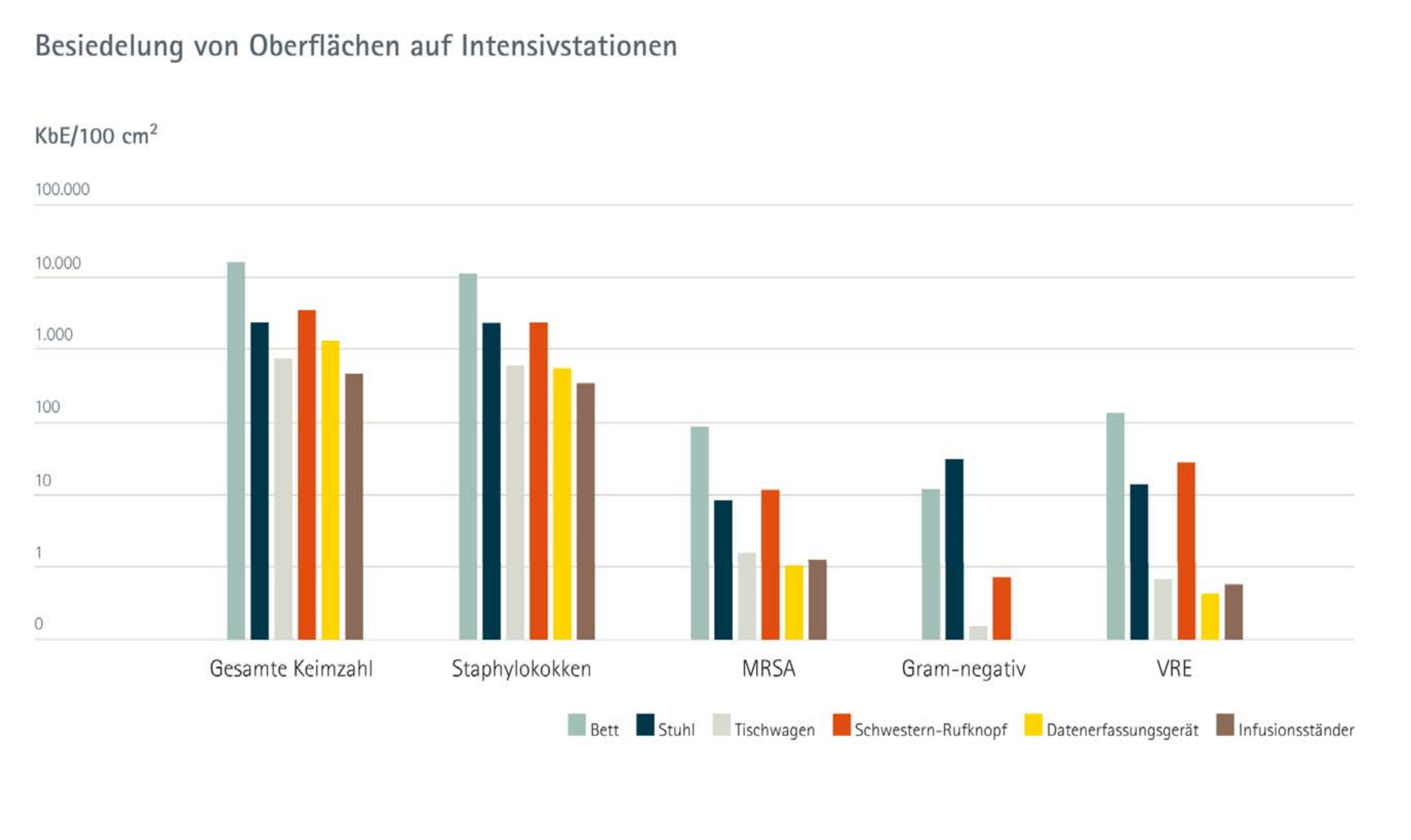
Quelle: Schmidt, M., Attaway Iii, H.H., Fairey., S.E. et al. (2013) Copper continuously limits the concentration of bacteria resident on bed rails within the intensive care unit. Infection Control and Hospital Epidemiology (ICHE), 34(5)

Antimikrobielle Kupferwerkstoffe in der Praxis

(3): Praxistests im Krankenhaus – Bsp. USA

- Finanziert vom US-Verteidigungsministerium:
- Untersuchungen auf Intensivstationen von 3 unterschiedlichen Krankenhäusern:
    - Memorial Sloan-Kettering Cancer Center (New York City)
    - Medical University of South Carolina (Charleston)
    - Ralph H. Johnson VA Medical Center (Charleston, S.C.)

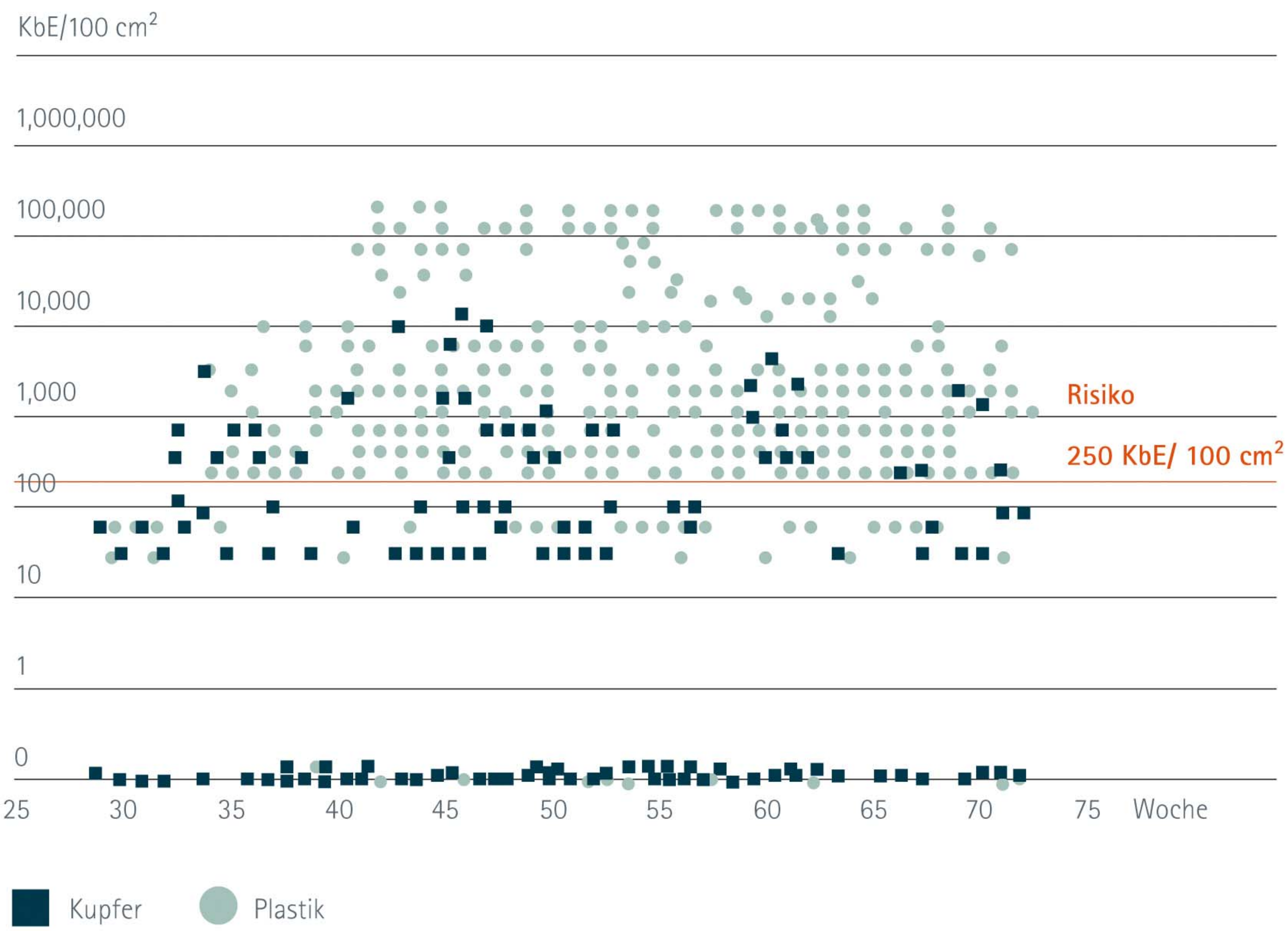
Klinische Studien – weltweit



Quelle: Schmidt, M., Attaway Iii, H.H., Fairey., S.E. et al. (2013) Copper continuously limits the concentration of bacteria resident on bed rails within the intensive care unit. Infection Control and Hospital Epidemiology (ICHE), 34(5)

Antimicrobial Copper Cu+

Besiedlungsuntersuchungen auf Bettgittern



Quelle: Schmidt, M., Attaway Iii, H.H., Fairey., S.E. et al. (2013) Copper continuously limits the concentration of bacteria resident on bed rails within the intensive care unit. Infection Control and Hospital Epidemiology (ICHE), 34(5)

Klinische Studien – weltweit

2008/2009: Asklepios Klinik Wandsbeck, Hamburg

- Onkologisch-pneumologische/ geriatrische Station
- Austausch von 50 Türgriffen/-platten und Lichtschaltern
- Reduzierung der MRSA-Keime auf 63 %
- Trend zu niedrigeren Infektionsraten

Appl Microbiol Biotechnol (2010) 87:1875–1879
DOI 10.1007/s00253-010-2640-1

APPLIED MICROBIAL AND CELL PHYSIOLOGY

Survival of bacteria on metallic copper surfaces in a hospital trial

André Mikolay · Susanne Huggett · Ladji Tikana · Gregor Grass · Jörg Braun · Dietrich H. Nies

Received: 12 March 2010 / Revised: 19 April 2010 / Accepted: 19 April 2010 / Published online: 7 May 2010

Abstract Basic chemistry of copper is responsible for its Janus-faced feature: on one hand, copper is an essential trace element required to interact efficiently with molecular oxygen. On the other hand, interaction with reactive oxygen species in undesired Fenton-like reactions leads to the production of hydroxyl radicals, which rapidly damage cellular macromolecules. Moreover, copper cations strongly bind to thiol compounds disturbing redox-homeostasis and may also remove cations of other transition metals from their native binding sites in enzymes. Nature has learned during evolution to deal with the dangerous yet important copper cations. Bacterial cells use different efflux systems to detoxify the metal from the cytoplasm or periplasm. Despite this ability, bacteria are rapidly killed on dry metallic copper surfaces. The mode of killing likely involves copper cations being released from the metallic copper and reactive oxygen species. With all this knowledge about the interaction of copper and its cations with cellular macromolecules in mind, experiments were moved to the next level, and the antimicrobial properties of copper-containing alloys in an "everyday" hospital setting were investigated. The alloys tested decreased the number of colony-forming units on metallic copper-containing surfaces by one third compared to control aluminum or plastic surfaces. Moreover, after disinfection, repopulation of the surfaces was delayed on copper alloys. This study bridges a gap between basic research concerning cellular copper

A. Mikolay · D. H. Nies (✉)
Institut für Mikrobiologie,

Quelle: Mikolay, A., Huggett, S., Tikana, L. et al. (2010): Survival of bacteria on metallic copper surfaces in a hospital trial. Applied Microbiology and Biotechnology, 87(5): 1875-1879

Deutsche Gesundheits-einrichtungen rüsten um

Deutschlandweit werden antimikrobielle Kupferbauteile in Gesundheitseinrichtungen eingesetzt

Antimicrobial Copper Cu+

Türgriffe, Handläufe und Schalter

Betten und Möbel

Kommunikations- und Schreibgeräte

Medizinprodukte

Deutsche Gesundheitseinrichtungen rüsten um

Pädiatrische Intensivstation am Allgemeinen Krankenhaus Hagen, Nordrhein-Westfalen

- Austausch von herkömmlichen Kontaktflächen auf der Kinder-Intensivstation und der Milchküche durch antimikrobielle Kupferbeschläge
- Einbau von Lichtschaltern und Bettengriffen aus antimikrobiellen Kupferlegierungen
- Weitere Umrüstungen in Planungen

Antimicrobial Copper Cu+

Deutsche Gesundheitseinrichtungen rüsten um

Evangelisches Geriatriezentrum Berlin

- Ausbau einer neuen Station mit Kupfer-Türklinken

Klinik für Kinder- und Jugend-medizin am Klinikum Niederberg

- Umrüstung der pädiatrischen Fachabteilung/ Kinderintensivstation auf antimikrobielle Kupfer-Türklinken

Deutsche Gesundheitseinrichtungen rüsten um:

Klinik für Kinder- und Jugendmedizin
Klinikum Niederberg, Nordrhein-Westfalen

- 2013: Umrüstung der pädiatrischen Fachabteilung/Kinderintensivstation auf Türklinken aus antimikrobiellen Kupferlegierungen

- Finanzierung über den Förderverein der Kinderklinik

Antimicrobial Copper Cu+

26 Länder, in denen weltweit antimikrobielle Kupferanwendungen realisiert wurden (Anzahl der Installationen > als 100).

Auf allen Kontinenten im Einsatz: antimikrobielle Kupferbauteile zur Infektionsprävention

1 Südafrika
2 Australien
3 China
4 Indien
5 Japan
6 Südkorea
7 Taiwan
8 Österreich
9 Belgien
10 Bulgarien
11 Republik Zypern
12 Finnland
13 Frankreich
14 Deutschland
15 Griechenland
16 Irland
17 Niederlande
18 Polen
19 Spanien
20 Schweiz
21 Großbritannien
22 Mexiko
23 USA
24 Brasilien
25 Chile
26 Peru

Antimicrobial Copper

Zusammenfassung und Ausblick

- **Im Gegensatz zu Beschichtungen, die sich mit der Zeit abnutzen, bieten massive Kupferlegierungen eine dauerhaft wirksame Lösung.**

- **Offenbar minimieren Kupferlegierungen mit ihrer antimikrobiellen Wirksamkeit die indirekte Keimübertragung.**

- **Diese Wirksamkeit geht auch im Falle nutzungsbedingter Beschädigungen der Oberfläche nicht verloren.**

Antimicrobial Copper

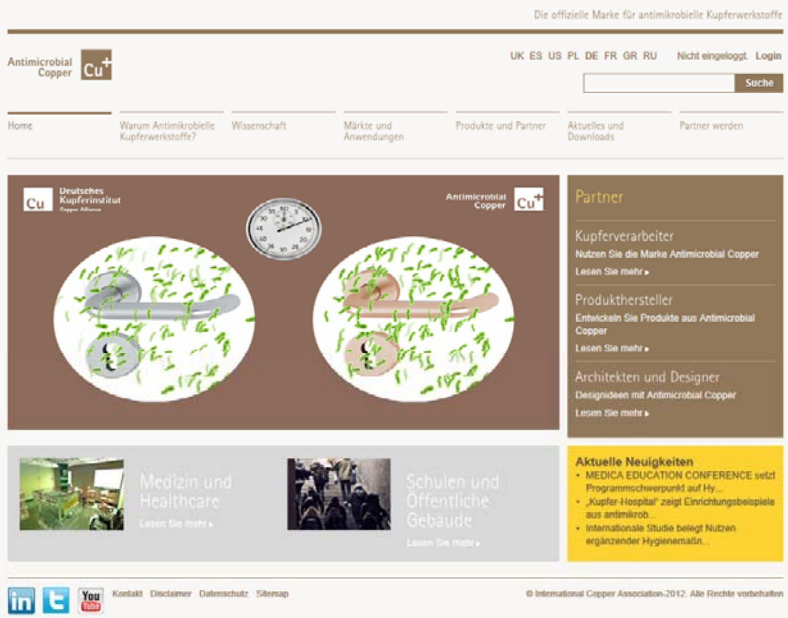
Kupferwerkstoffe sind die Werkstoffe, die wirken - dauerhaft, ununterbrochen und zuverlässig.

Sie sind damit eine ideale Ergänzung zu Desinfektions-mitteln, die überwiegend kurzzeitig nach der Anwendung wirken, und sie gestatten die Vermeidung persistenter Stoffe mit ihren inhärenten Toxizitätsproblemen.

+

+

Wo gibt es mehr Informationen über antimikrobielle Kupferwerkstoffe?



www.antimicrobialcopper.org

Wo gibt es mehr Informationen über antimikrobielle Kupferwerkstoff?

…an unserem Stand B12

Wir freuen uns auf Sie!

Vielen Dank für Ihre Aufmerksamkeit!

Antimicrobial Copper Cu+ ™